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Development in Sunbed Use 2007-15 and Skin Cancer Projections of Campaign Results 2007-40 in the Danish Population

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Keywords: Skin Cancer, Prevention, Malignant Melanoma Projections, Campaign, Ultraviolet Radiation, Questionnaire

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Brian Køster affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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Abstract

Objective: To evaluate campaign effects 2007-15 on prevalence of sunbed use and to use these results to model future effects on skin cancer incidences.

Design: The study is a longitudinal, cross-sectional design

Setting: Exposure to ultraviolet radiation is the main risk factor for skin cancer. Denmark has the highest prevalence of sunbed use reported and one of the highest incidence of skin cancer worldwide.

Participants: During 2007-15, survey data was collected for 37.766 Danes, representative for the Danish population in regards to age, gender and region.

Interventions: In 2007, a long-term anti-sunbed campaign was launched in Denmark.

Primary and secondary outcome measures: Sunbed use was evaluated by annual cross-sectional surveys. Skin cancer incidence was modelled in the Prevent program, using population projections, historic cancer incidence, sunbed use exposure and relative risk of sunbed use on melanoma.

Results: The prevalence of sunbed use in Denmark was reduced to 30 % of the pre-campaign level. The campaigns results during 2007-15 is estimated to reduce the number of skin cancer cases with more than 10.000 (1574 MM, 3159 SCC, 5657 BCC) totally during 2007-40. Keeping the 2015-level of sunbed use constant by a continued campaign pressure or structural interventions would potentially avoid more than 1400 skin cancer cases annually in 2040 and 30.000 skin cancer cases in total during 2007-40.

Conclusion: We have shown the value of prevention and the value of long term planning in prevention campaigning. Sunbed use was reduced significantly during 2007-15 and further reductions are possible by structural interventions. Consequently, significant fewer skin cancer cases are anticipated. The Danish parliament has population support to enforce structural interventions to avoid a large burden of this disease.

Strength and Limitations

- Long term funding and planning secured the continuity in this prevention campaign, the high campaign pressure and the achievements of milestones
- The campaign was composed of 50 % creative campaign personnel and 50 % scientific evaluation personnel, to form an intelligent campaign in an iterative construction
- Projection models can be influenced by changes in improved diagnostics, equipment, change in strength of UV spectrum or output in sunbeds or other changes in population UV-exposure

Introduction

Exposure to ultraviolet radiation (UVR) is the main risk factor for keratinocyte skin cancers (SCC and BCC) and malignant melanoma (MM) skin cancer (1, 2). Intermittent exposure to UVR from the sun and sunbeds, and sunburn history, are important factors in the etiology of skin cancer (3, 4). In Denmark, the MM incidence (world standardized rate per 100 000) for men and women increased from 1.4 and 1.9 in 1949–1953 to 21.4 and 26.7 in 2010–2014, respectively (5). Similarly, keratinocyte skin cancer incidences increased manifold in the same period. Presumably as a consequence of improved primary and secondary prevention, improved diagnostics (6, 7) and change in sun exposure patterns including increased travelling since the 1960's and introduction and spread of sunbed facilities in the 1980's. Half of the Danish population travel to sunny destinations each year (8, 9), approximately 60 % have ever used a sunbed (10) and 40 % were sunburnt annually (8, 11).

In 2009, the International Agency for Research on Cancer classified ultraviolet- emitting tanning devices as 'carcinogenic to humans' with respect to MM (12). (4, 13-16). The increased risk of MM was especially high among sunbed users younger than 30-35 years, where more than 75% of cases diagnosed in this young age was caused by the sunbed use. Sunbed use was shown to increase the risk of MM without the presence of sunburn (14, 16). Boniol et al. summarized the risk of MM from sunbed use in a systematic review to be 1.2 for ever-use and 1.59 for use initiated before the age of 35. Additionally, a dose response relationship was established between frequency of sunbed use and MM with an increased risk of 2 % for each extra annual session (17). The increased risk, from sunbed use, of developing basal cell carcinoma and squamous cell carcinoma was summarized by Wehner et al. (18) to 1.29 and 1.67, respectively. Sunbed use is highly prevalent in Denmark, especially in younger age groups and more than half of those recalling their age of initiation of sunbed use reported start before age 18 (19, 20). Sunbed use was estimated to be responsible for 13 % and 8 % of MM cases in Denmark in women and men (17).

Campaign content

In 2007, an anti-sunbed campaign was launched, with young people aged 15–25 as the primary target. The campaign was based mainly on social media and also magazines and radio, the traditional youth targeted media. The campaign was very successful, with viral dissemination of video clips, music videos and other materials that made links between sunbed use, negative cosmetic effects and skin damage and educational programs including a pocket movie competition in 7th graders making them ambassadors for anti-sunbed campaigning.

The public activities included lobbying at national and local government levels and a public campaign programme. The lobbying focused on legal prohibition of sunbed use for children under 18 years of age and the removal of sunbeds from, e.g. local sport facilities and pools under local government administration. In summer 2009, politicians spoke out in favour of legal restriction of sunbed use by children under 18 years of age. During spring and summer of 2009, some local governments started removing sunbeds from public facilities, and in 2017 the majority of local governments have removed sunbeds from their buildings. Only six out 98 local governments still have sunbeds in their buildings and in 2 of those age restrictions (<18 y) have been implemented. However, the majority of sunbed operators in Denmark are commercial and not influenced by these restrictions. The campaign generated press coverage and political debate, which raised public awareness of the health risks associated with sunbed use, included more than 2700 press clips on sunbed topics during the period of the study.

We studied the development in sunbed use in Denmark after the start of a 10-year national sun protection campaign in March 2007. The aims of this study is 1) to show the possible effects of the Danish Sun Safety Campaign on prevalence of sunbed use and 2) to estimate potential reductions in future skin cancer incidence by the campaign.

Materials and Methods

Overview

We estimated the effect of the Danish Sun Safety Campaign during 2007-15 in terms of annual reduction in the fraction of ever users of sunbed. We modelled projections of future cancer incidence, introducing the effects of the campaign and compared with status quo using realistic estimates of relative risks in the intervention scenarios to obtain an indication of the long-term impact of the campaign interventions on cancer incidence.

Questionnaire and confounding

During 2007-2015, a question on frequency of sunbed use was included in the annual population-based questionnaires on exposure to UV radiation and behavior and attitude towards UV exposure. In total, 37.766 Danes answered the 75-item questionnaire. Data was collected by computer assisted web interview (CAWI) by Epinion (2007 and 2014-15) and Userneeds (2008-13). Data was collected as representative for the Danish population by gender, age, region and education. The education variable included 7-10 options during the period and it was condensed into the three categories as shown in table 1. For the initial measurements in 2007, there was no higher age limit and persons 65 and older were categorized as missing to be able to compare to following measurements. Since 2009, a limited number of internet panels were available, which were able to provide the respondent structure requested. To avoid measuring only effect in the panel and not in the population, it was a requirement that maximum 25 % of the participants were allowed to participate in the survey the following year, because answering a questionnaire could influence the behavior.

Exposure to artificial UVR was determined by the question: ('How often did you use a sunbed within the past 12 months?': 'More than once a week, Once a week, More than once a month, Once a month, Fewer than four times a year, Not within the past twelve months, Never'); The questionnaire also elicited information on behaviour with respect to exposure to natural UVR; these results will be reported separately. The question about sunbathing was included in the analysis to distinguish between intentional and non-intentional tanning (1). As data collection and panel composition evolved as well differences exist between years. Age was included in all analysis as five or 10-year age groups. Teenagers were kept as '15-19 years' as their behavior was shown to differ from that of the adult population (21, 22). Skin types were determined from self-assessed tan and sunburn reactions, according to Fitzpatrick skin type I (never tan, always burn) to skin type IV (always tan, never burn)(23).

The accumulated sun hours and average temperature of June and July was included in the regression analysis as Danes could be more prone to use sunbed when the weather conditions makes outdoor sunbathing impossible and significant variation in weather measures occurred during the period analyzed.

Patient involvement

The Danish Sun Safety Campaign has continuously used information from for example interviews and focus groups with patients, at-risk groups and lay people in an iterative setup to improve campaign elements as well as annual evaluations of the campaign. Recruitment is described above and dissemination of results will be by scientific publication, national press as well as patient organization newsletters from the Danish Cancer Society.

Analysis

Answers to sunbed use were grouped into 'recent users' and 'non-recent users' and 'ever users' and 'never users', respectively. Recent use was defined as use within the past 12 months. Similarly, ever-use of sunbed was defined as belonging to all categories except the 'never' category. The homogeneity of respectively recent and ever sunbed use over time of survey and demographic variables was examined. The outcome 'sunbed use, yes / no' was analysed using logistic regression. The factors included in the model, as categorical variables, were gender, age, education, skin type, having children below age 18 in household and region. Factors with a statistically significant different distribution were included as possible explanations. Adjusted odds ratios (ORs) and 95% confidence intervals (CIs) were calculated. The *p*-values from the logistic regression analysis refer to either tests for variation between the factor levels by time (year) or trend as stated for the relevant analysis. For all tests, P values < 0.05 were considered statistically significant. The procedure logistic in SAS version 9.3 (SAS Institute, Cary, NC, USA) was used for the analyses.

The prevent model

Projection of future incidence was estimated using Prevent (24, 25). This program was adapted for the Eurocadet project to model future cancer incidence by implementation of lifestyle preventive strategies. Prevent calculated the percentages of potentially prevented cases under the scenario of interest as compared to the status quo scenario. If the scenario of interest is no exposure or exposure with minimum impact on risk, this percentage is interpretable as the population attributable fraction (PAF) of sunbed use experience, respectively, on skin cancer (MM, SCC, BCC) incidence by the year 2040: they represent the numbers of cases that would be prevented had the population not used sunbed and therefore the fraction of MM, SCC and BCC cases attributable to these risk factors. Three types of data are needed to run the model; demographic data (current and projected population sizes by age and sex), risk factor-related data (prevalence, changes in prevalence as a result of interventions and risk estimates) and disease incidence data (cancer rates and estimated annual percentage change to account for trends in disease incidence that are not associated with modelled risk factor data). The projected numbers of new cancer cases were computed based on the demographic data and under different scenarios of changes in the prevalence of risk factors. Results are projected rates and numbers with and without modelled interventions by risk factor prevalence

Exposure: Sunbed use

The prevalence of sunbed use was derived from sun behavior questionnaires of The Danish Sun Safety Campaign as described above. The campaign was the only initiative in Denmark collecting data on UVR exposure continuously since 2007 (8, 11, 26-29). In the Prevent model, sunbed use was included as ever/never use. The change in prevalence of sunburn applied in the population projections was from logistic regression analysis.

Incidence data

National incidence rates for melanoma and keratinocyte skin cancer (ICD-10 code: C43 and C44) by sex and 5-year age groups were retrieved from NORDCAN (5). The estimated annual percentage change (EAPC) for men and womenfor the past 25 years, respectively, was 6.4 % and 10.9 % increase for SCC, 5.4% and 7.4 % for BCC and 4.4 % and 4.5 % for melanoma (5). We chose to use a uniform conservative 4% increase in all skin cancer rates for men and women for the modelling. The EAPC was applied for the first 15 years after which it remained constant at this level. For sensitivity analysis, we applied an EAPC respectively of 0 and 30 years.

Population projections

From Statistics Denmark we obtained the size of the population on January 1st, of the corresponding period of the latest available incidence data by 1-year age category and sex as well as forecasted population sizes for each year up to 2040 by 5-year age categories and sex, using the medium national growth estimates.

Effect of sunbed use on the incidence of melanoma skin cancer.

Relative risks for sunbed use on the risk of MM and keratinocyte cancers were derived from the largest meta-analysis', on the subject, established by respectively Boniol et al. and Wehner et al. MM: RR= 1.2 for >35-year-olds and RR=1.59 for <35-year-olds and RR for SCC and BCC of 1.67 and 1.29 respectively. (17, 30). These findings were used as the relative risks and risk functions in our modelling (fig. 1). The relative risks and risk functions were assumed equal for all age groups within age bands and included in the study, and across time. The effect of a risk factor exposure on cancer incidence has a latency time. Prevent accommodates this through two time lags: (1) the time that the risk remains unchanged after a decline in risk factor exposure (LAT) and (2) the period during which the changes in risk factor exposure gradually affect the risk of cancer, eventually reaching risk levels of the non-exposed (LAG)(24). For this study, we used for sunbed use a LAT of 2 years and a LAG of 5 years for MM and respectively 2 and 8 years for keratinocyte cancers. LAG was modelled as a linearly declining risk. As LAT and LAG for sunbed use on risk of MM has not been estimated precisely, short time periods were chosen from the knowledge of intermittent exposure pathway (1) and the experiences from Iceland (31) and sunbed use in young people (13).

We have modelled the development in future skin cancer Incidence in Denmark in three scenarios. We have used the reductions in sunbed use during 2007-15 to model MM Incidence in 2007-40.

- Scenario 1) We assume the campaign is discontinued after 2015 and that the rate of sunbed use remains constant afterwards (Irreversible campaign effect)
- Scenario 2) Similar to scenario 1 except, we have modelled a conservative 'spring effect' where the prevalence of sunbed use returns to pre campaign level in the inverse rate as it was reduced 2015-2023 (reversible campaign effect)
- Scenario 3) The expected trend if prevalence of sunbed use is unchanged (trend/no campaign effect)

We have also applied sensitivity analyses to the conservative scenario 2. We have used the applied EAPC for 0, respectively 30 years instead of 15. We have applied a combined LAT+LAG time of either zero or twice the time, of the original scenario.

Results

Table 1 shows the distribution of demographic characteristics from annual data collections during 2007-15. Answers were collected from more than 4000 persons/survey, except for 2012 and 2014 were 2000 persons/survey was settled for due to challenges with data collection of certain groups, especially young (15-19 y) men. For all included variables, we found significant variation over years. Only 2007 data collections differed for gender, after which sampling methods were optimized. In 2007 there was no higher limit for age, however in this analysis persons older than 65 were excluded, which lead to differences in the distribution of age compared to 2008-15. There was more people characterized with paler skin types in 2013-15. Region and education was not used in the sampling all years, which mean that e.g. august 2007

data are overrepresented by persons from region capital. Education was differently distributed in panels and in panel characterizations of education between years. Persons who reported sunbathing declined during the campaign period. Persons having children 18 or younger staying at home also varied. Weather varied randomly for the variables mean temperature, mean monthly number of sunhours and mean monthly days with rain.

Supplemental table S1a and b shows the detailed distribution of sunbed use, recent and ever-use respectively. In all the annual surveys, there are differences for all included variables except having children. In general, more women used sunbed and sunbed use decreased by age. More persons with dark skin types used sunbed and sunbed use was more prevalent in Northern Jutland and the less prevalent in region Capital. Fewer persons with more than 12 years of education used sunbed, while more persons who sunbathed also use sunbeds.

Figure 2a and b shows the adjusted odds-ratio (OR) and 95 C.I: of the development in sunbed use adjusted for gender, age, education, region and skin type, with the March 2007 measurement as reference point. The decrease in sunbed use was largest in the beginning of the campaign period and until about 2011/12, where the decrease leveled. In 2015, the level of sunbed use had approximately decreased to 30 % of the pre-campaign measurement in March 2007.

Table 2 (ever-use) and supplemental table S2 (recent use) shows the logistic regression analysis of the sunbed use in Denmark by demographic factors in the left part of the table and in the right part is shown the annual percentage change in sunbed use. Age and skin type are the variables most influential on sunbed use. We have shown crude OR (95 C.I.), a model adjusted for gender, age, skin type, region, education and having children below 18 in household. Due to the large differences in education in our analysis of the development of sunbed use, we also tried to exclude education, but that did not change the estimates significantly. In addition, we also examined the influence by weather parameters in a model additionally adjusted for temperature, number of sunhours and days with rain. We found that increasing temperature, number of sun hours and number of days with rain was associated with increased sunbed use. In the right side of tables 2 and S2 is shown the crude reduction by annual measurement. Females reduced their recent sunbed use more than men and young persons more than older persons, especially the 15-19-year-olds. People educated less than 10 years reduced their sunbed use more than longer educated persons. No significant differences in reduction by skin type, region, sunbathing or among people with or without children. Overall, the adjusted analysis showed an OR of 0.94 corresponding to a reduction of 6 % annually in the campaign period. For recent use of sunbed the reduction was 18 % annually.

The prevalence of sunbed use influence on future MM incidence

In figure 3a-c, we have modelled the development in the number of future MM, SCC and BCC Incidence cases according to scenarios 1-3 in Denmark. The effect of the campaign results in a reduction of 195 MM, 488 SCC and 731 BCC skin cancer cases pr. year in 2040 and in total 4649 MM, 9752 SCC and 16161 BCC cases during 2007-40, while if the effect of the campaign is reversed to pre-campaign level there will be no change in annual number of skin cancer cases in 2040 but a total reduction of 1574 MM, 3159 SCC and 5657 BCC cases during 2007-40. The results of the skin cancer reductions projections including relative percentage reductions are summarized in table 3. The table also includes sensitivity analysis projections for scenario 2 where EAPC and LAT+LAG was examined. There was a minimum of 885 MM cases, respectively and a maximum of 1800 MM cases fewer during 2007-40. Likewise, there was a minimum/maximum of 6208/ 11972 fewer skin cancer cases totally 2007-40. The relative reductions are larger for irreversible

effects compared to reversible. The sensitivity analysis variations of scenario 2 were robust to changes in cancer incidence and time to effect.

Discussion

We have shown that the Danish Sun Safety Campaign reduced the sunbed use during 2007-15, to 30 % of the pre-campaign level. We have modelled these results in respect to future skin cancer incidences and expect more than 1400 fewer cancer cases annually in 2040 and more than 30.000 fewer cases totally until 2040, as the campaign is still ongoing. Had the campaign been terminated after 2015, it may not influence the annual number of skin cancers in 2040, however during 2007-40 still more than 10.000 skin cancer (MM, SCC and BCC) cases would have been avoided.

Strengths and limitations

The unique strengths of this study is the possibility of long time planning, securing the continuity in the campaign including comparable wordings in the questionnaires and personnel to secure comparable evaluations over the entire period as well as long term funding has made the high continuous campaign pressure possible.

There is a risk that the high awareness created by the campaign could cause political correctness bias meaning e.g. that persons would falsely state no to sunbed use in questionnaires. Similarly selection bias may occur, e.g. that sunbed users would be less prone to participate in surveys of this subject.

Regarding a prognosis of the cancer incidence in absolute numbers, there are unknown indicators we are not able to include in the model like improved diagnostics, equipment, change in strength of UV spectrum or output in sunbeds (6, 32) or other changes in UV-exposure. However as we are using the difference between two cancer incidence rates this has minor influence on results. The prevent model primarily gives useful measures of the influence of change in use of sunbeds.

The reason that the number skin cancer cases in the years already passed is different from the actual incidence development is that other factors are involved. About year 2002-04 the dermatoscope was introduced among dermatologists in Denmark, which probably increased the rate of detection (6) in a period. In the following period a plateau is seen from around 2011 (5). Most likely, the decreased incidence rate is a consequence of the earlier detection/treatment, an effect also seen in various screening programs. While the increasing skin cancer incidences raised the awareness in the media of the disease up through the ‘90s in 2007, the multi component Intervention of the Danish Sun Safety Campaign increased this awareness manifold. The increased awareness could also lead to an increase in mole check by the general physician which again could lead to an increased number of diagnoses. We were not able to measure this.

Reduction in sunbed use

Denmark had one of the highest reported frequencies of sunbed use in the world before the Danish Sun Safety Campagin was launched. Even though large reductions have taken place, our prevalence of sunbed use is now just comparable to other European countries, e.g. 14 % within the past year in Germany in 2012 (33). Concerning campaign efficiency, there have been anti-sunbed campaigns in e.g. UK, Canada, US and Australia, which have also shown reductions, however our baseline use are not similar and comparable. The past years of the reductions in sunbed use has leveled of perhaps as a consequence of a different focus of

the Danish Sun Safety Campaign towards sunny holidays or perhaps the remaining users are less perceptible of risk communication.

Consequences and recommendations

Others have previously modelled cancer incidence, e.g. Pil et al. (34) have modelled the effect of various scenarios thought to prevent skin cancer. Our results are based on an actual intervention with measurable results of the exposure; therefore, our modelling results of future cancer incidence are a realistic prognosis of the incidence change. Likewise, we have shown the importance of a continued campaign pressure to achieve these goals (difference between model 1 and 2).

The WHO suggests countries bans sunbeds or alternatively restrict (staff supervision, age limit, high-risk individuals), manage (license, radiation output and time limits, staff training, tax) and inform (health risks, display warning, ban marketing) to protect their populations (35). In 2017, the majority of countries in Western Europe and the majority of American states have introduced age limits for sunbed use to protect children, and states with age limits succeeded in reducing the prevalence of sunbed use (36). Furthermore, the first countries, Australia and Brazil has completely banned sunbed use to protect their population against the detrimental effects of sunbed use on human health and to reduce government spending related to skin cancer diagnostics and treatment (37). Belgium is to our knowledge the first European country to recommend a ban against sunbed use (38), while Denmark is now one of few remaining western European countries without an age limit to protect children (39).

With the health potential of the achieved results, we hope to motivate government administrations to implement structural interventions to reduce the sunbed use in Denmark as well as in countries with similar problems as in Denmark. We specifically emphasize the need for a revision of the Danish sunbed legislation adopted in 2014.

Conclusion

The Danish Sun Safety campaign has significantly reduced the sunbed use in Denmark. Several legislative restrictive measures exists which would be beneficial to introduce to reduce the sunbed use further at the current stage and to avoid that the sunbed use increases again if campaigning is not available. As a consequence of the campaign, we expect fewer skin cancer cases in Denmark in the future. Danish politicians have the opportunity, supported by the population, to reduce the skin cancer incidences further and thereby to reduce the future costs of skin cancer.

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Conflicts of interest

The authors have declared that no competing interests exist. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Data sharing: Full dataset available from the corresponding author.

Authorship Contribution Statement

BK, MM, TA, GE and PD have contributed to conceptualization and design of the study, analysis and interpretation of data, critical revision of the manuscript and final approval of the manuscript. BK drafted the manuscript.

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Table 1. Distribution of demographic characteristics in cross-sectional surveys on UV-exposure 2007-2015 of 37.766 Danes.

Characteristic **(%)**	Total (n)	% or mean	March 2007 (%)	August 2007	August 2008	August 2009	August 2010	August 2011	August 2012	August 2013	August 2014	August 2015
Total (n)	37766	**100**	4303	4451	4277	4186	4156	4130	2195	4022	2047	3999
Gender	*p<0.001*											
Male	18437	**49**	44	44	50	50	50	50	50	50	50	50
Female	19300	**51**	56	56	50	50	50	50	50	50	50	50
Agegroup	*p<0.001*											
15-19	3417	**9**	8	8	10	9	10	9	9	10	10	10
20-29	6017	**16**	9	8	18	17	17	17	17	19	19	20
30-39	7409	**20**	20	20	16	21	21	21	21	19	19	18
40-49	8442	**23**	21	23	23	22	22	22	22	23	22	22
50-59	7547	**20**	20	19	24	20	20	20	20	19	18	18
60-64	3933	**10**	11	10	8	11	10	10	10	11	12	12
missing	1001	**3**	11	11	0	0	0	0	0	0	0	0
Skintype	*p<0.001*											
I	4550	**12**	12	10	11	10	10	11	11	16	15	15
II	19316	**51**	51	51	52	52	53	54	51	48	50	50
III	12203	**32**	34	35	33	34	34	32	33	29	31	28
IV	735	**2**	3	3	2	2	2	1	2	2	2	2
missing	962	**1**	1	1	1	1	1	1	1	1	1	1
Region	*p<0.001*											
Capital	13065	**35**	39	46	33	32	32	32	31	32	32	32
Zealand	4680	**12**	11	9	13	12	12	12	15	14	14	14
Northern Jutland	7028	**10**	10	9	10	11	10	10	10	10	10	10
Central Jutland	8086	**21**	21	18	21	22	21	22	23	23	21	23
Southern Denmark	3749	**19**	16	14	18	18	19	18	22	21	23	21
Missing	1158	**3**	3	3	5	5	6	5	0	0	0	0
Education	*p<0.001*											
< 10 years	9372	**25**	18	16	31	32	28	29	28	28	8	24
10-12 years	14881	**39**	29	28	44	45	49	49	42	40	27	42
>12 years	12909	**34**	54	55	25	22	22	21	28	31	64	32
Missing/unspecified	604	**2**	1	1	2	2	2	2	2	1	1	2
Sunbathe	*p<0.001*											
Yes	24350	**64**	72	61	65	67	65	61	60	64	66	63
No	13416	**36**	28	39	35	33	35	39	40	36	34	37
Have children	*p<0.001*											
Yes	12527	**33**	35	36	32	33	33	34	25	34	34	32
No	25239	**67**	65	64	68	67	67	66	75	66	66	68
Temperature	*p<0.001*	**15.8**	17.4	15.9	16.3	15.6	16.3	15.8	14.3	15.7	17.2	14.1
Sunhours	*p<0.001*	**241**	285	197	281	250	248	212	203	254	274	210
Days with rain /month	*p<0.001*	**14.4**	8.5	18	13.5	15.2	11.9	15.6	19.4	12.3	13.3	16.2

p-values are for χ^2-test between factor levels and year of measurement. Values are percentage except for weather variables which are expressed in means.

Table 2 Logistic regression analysis of sunbed use (ever use) in Denmark 2007-2015 by demographic factors and annual percentage decrease in sunbed use overall and by factor levels.

Characteristic **(%)** Total (n)	Total (n)	% or mean	Crude OR (95 C.I.)	[a)]Adjusted OR (95 C.I.)	[b)]Adjusted OR (95 C.I.)	Sunbed use annual percentage decrease	Sunbed use change by annual measurement (adjusted)
Total (n)	37562	18	34616	34616	34616	0.95 % (0.94-0.95)	**0.94 % (0.94-0.95)**
Gender			*p<0.001*	*p<0.001*	*p<0.001*		
Male	18325	13	1 (ref)	1 (ref)	1 (ref)	0.98 % (0.96-0.99)	
Female	19237	22	2.78 (2.66-2.90)	3.02 (2.88-3.16)	2.66 (2.53-2.79)	0.93 % (0.92-0.94)	
Agegroup			*p<0.001*	*p<0.001*	*p<0.001*		
15-19	3383	27	1.38 (1.25-1.53)	1.30 (1.17-1.44)	1.03 (0.92-1.15)	0.80 % (0.78-0.83)	
20-29	5970	25	3.22 (2.95-3.51)	3.28 (2.99-3.61)	3.06 (2.78-3.37)	0.85 % (0.83-0.86)	
30-39	7369	19	4.37 (4.01-4.76)	4.53 (4.11-4.98)	4.78 (4.33-5.28)	0.92 % (0.90-0.94)	
40-49	8419	18	2.97 (2.74-3.23)	3.01 (2.75-3.30)	2.95 (2.69-3.24)	1.00 % (0.99-1.02)	
50-59	7529	12	1.49 (1.37-1.62)	1.48 (1.36-1.62)	1.45 (1.32-1.58)	0.99 % (0.98-1.01)	
60-64	3922	8	1 (ref)	1 (ref)	1 (ref)	0.98 % (0.96-1.00)	
Skintype			*p<0.001*	*p<0.001*	*p<0.001*		
I	4534	13	1.08 (0.92-1.28)	0.64 (0.54-0.76)	0.80 (0.66-0.95)	0.95 % (0.93-0.97)	
II	19252	18	1.19 (1.02-1.36)	0.92 (0.78-1.09)	0.99 (0.83-1.17)	0.95 % (0.94-0.95)	
III	12141	19	0.96 (0.82-1.13)	0.90 (0.76-1.07)	0.93 (0.78-1.10)	0.95 % (0.93-0.96)	
IV	733	23	1 (ref)	1 (ref)	1 (ref)	0.95 % (0.91-1.00)	
Region			*p<0.001*	*p<0.001*	*p<0.001*		
Capital	12998	15	1 (ref)	1 (ref)	1 (ref)	0.95 % (0.94-0.96)	
Zealand	4652	16	0.88 (0.82-0.97)	1.15 (1.04-1.27)	0.99 (0.92-1.07)	0.95 % (0.93-0.97)	
Northern Jutland	3730	21	1.17 (1.08-1.26)	0.93 (0.87-1.01)	1.30 (1.20-1.42)	0.95 % (0.93-0.97)	
Central Jutland	8042	19	1.08 (1.02-1.14)	1.15 (1.08-1.22)	1.18 (1.10-1.25)	0.93 % (0.91-0.94)	
Southern Denmark	6985	18	0.99 (0.94-1.06)	1.08 (1.01-1.15)	1.11 (1.04-1.19)	0.95 % (0.94-0.97)	
Education			*p<0.001*	*p<0.001*	*p<0.001*		
< 10 years	9313	17	0.64 (0.61-0.68)	1.01 (0.94-1.07)	1.10 (1.03-1.17)	0.94 % (0.92-0.95)	
10-12 years	7130	20	1.04 (0.99-1.09)	1.12 (1.06-1.19)	1.16 (1.10-1.22)	0.92 % (0.91-0.93)	
>12 years	7682	18	1 (ref)	1 (ref)	1 (ref)	0.97 % (0.96-0.98)	
Sunbathe			*p<0.001*	N.A	*p<0.001*		
Yes	24240	24	4.16 (3.85-4.49)		2.73 (2.59-2.87)	0.94 % (0.93-0.95)	
No	13322	7	1 (ref)		1 (ref)	0.98 % (0.96-0.99)	
Have children<18 in household			N *p<0.001*	*p=0.030*	*p=0.085*		
Yes	12461	18	1.55 (1.49-1.63)	1.06 (1.01-1.12)	1.05 (0.99-1.11)	0.94 % (0.93-0.95)	
No	25101	17	1 (ref)	1 (ref)	1 (ref)	0.95 % (0.94-0.96)	
Temperature (Degree celsious)			*p<0.001*	N.A	*p<0.001*		
			1.11 (1.08-1.13)		1.15 (1.11-1.19)		
Sunhours (/100/summer)			*p<0.001*	N.A	*p=0.004*		
			1.13 (1.08-1.19)		1.23 (1.07-1.42)		
Days with rain /month			*p<0.001*	N.A	*p<0.001*		
			0.99 (0.98-0.99)		1.04 (1.03-1.06)		

Odds ratios and confidence intervals (CIs). a) Model adjusted for gender, age, education, skin type, have children and region. b) Model additionally adjusted for sunbathing and weather indicators

Table 3 Projected change in number of skin cancer cases 2007-40 based on modelled scenarios of the change in sunbed use fraction 2007-15 in Denmark compared to trend.

	Projections based on campaign results 2007-15		Sensitivity variations of scenario 2			
Scenario	1 (Irreversible)	2 (Reversible)	EAPC0	EAPC30	LATLAG, Zero	LATLAG, Double
Total MM cases	111.353	111.353	63.104	154.525	111.353	111.353
Total SCC cases	136.999	136.999	83.108	184.766	136.999	136.999
Total BCC cases	414.817	414.817	254.859	547.749	414.817	414.817
ΔTotal MM	4.649 (4,2 %)	1.574 (1,4 %)	885 (1,4 %)	1.747 (1,1 %)	1.249 (1,1 %)	1.800 (1,6 %)
ΔTotal SCC	9.752 (7,1 %)	3.159 (2,3 %)	1.900 (2,3 %)	3.553 (1,9 %)	3.029 (2,2 %)	3.719 (2,7 %)
ΔTotal BCC	16.161 (3,9 %)	5.657 (1,4 %)	3.423 (1,4 %)	6.294 (1,1 %)	4.542 (1,1 %)	6.453 (1,6 %)

EAPC0 and EAPC30 corresponds to number of years with the estimated annual percentage change in incidence. Remaining years are constant. Main scenarios apply 15 years EAPC. LATLAG, Zero and Double, respectively is the time from an intervention is applied to the effect of the intervention on the risk factor affects the risk of cancer.

Figure legends

Figure 1

Illustration of data projections and scenarios

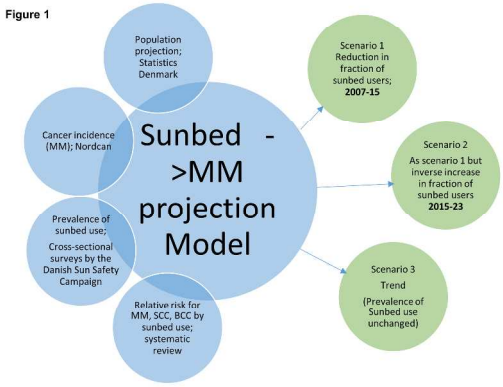
Figure 2A. Development in sunbed use (past 12 months) by time since campaign launch. Values are OR (95CI) sunbed use compared with 2007 pre-campaign measurement adjusted for gender, age, education, region and skin type.

Figure 2B. Development in sunbed use (ever use) by time since campaign launch. Values are OR (95CI) sunbed use compared with 2007 pre-campaign measurement adjusted for gender, age, education, region and skin type.

Figure 3a
The expected number of MM cases, when sunbed use is unchanged, there is a reversible or irreversible campaign effect. Assumed estimated annual percentage change 2007-2022 (4% increase) and 2022-2040 (0% constant). LAT time of 2 years and LAG time of 5 years.

Figure 3b
The expected number of SCC cases, when sunbed use is unchanged, there is a reversible or irreversible campaign effect. Assumed estimated annual percentage change 2007-2022 (4% increase) and 2022-2040 (0% constant). LAT time of 2 years and LAG time of 8 years.

Figure 3c
The expected number of BCC cases, when sunbed use is unchanged, there is a reversible or irreversible campaign effect. Assumed estimated annual percentage change 2007-2022 (4% increase) and 2022-2040 (0% constant). LAT time of 2 years and LAG time of 8 years.



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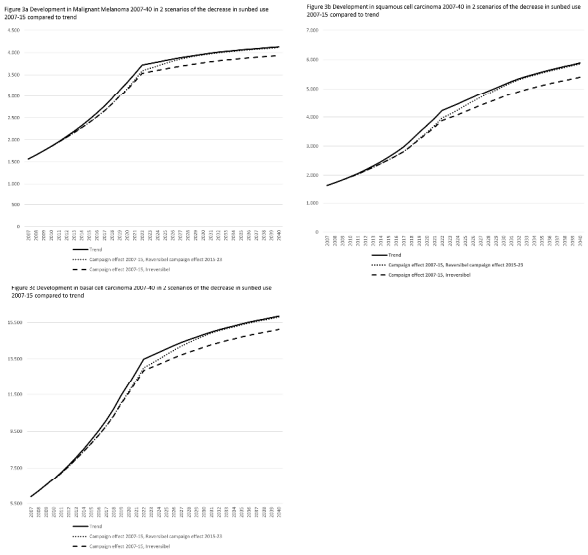

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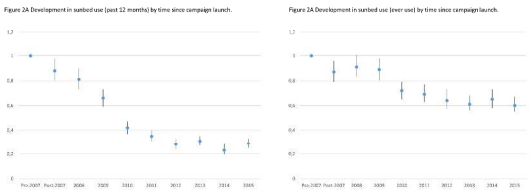

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Supplemental table S1a Percentage of sunbed use (past 12 months) by demographic characteristics and year of measurement in cross-sectional surveys in Denmark 2007-2015 of 37.766 Danes**.**

Characteristic **(%)** Total (n)	Total (n)	% or mean	March 2007 (%)	August 2007	August 2008	August 2009	August 2010	August 2011	August 2012	August 2013	August 2014	August 2015
Total (n)	37766	**18**	4303	4451	4277	4186	4156	4130	2195	4022	2047	3999
Gender	*p<0.001*		*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*
Male	18437	**13**	18	14	16	16	12	10	10	11	8	8
Female	19300	**22**	32	31	34	28	19	16	12	12	11	13
Agegroup	*p<0.001*		*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*0.008*	*p<0.001*	*p<0.001*	*p<0.001*
15-19	3417	**27**	50	48	44	33	18	12	9	13	14	15
20-29	6017	**25**	47	45	38	32	22	17	16	15	13	12
30-39	7409	**19**	31	31	28	22	14	15	11	10	8	10
40-49	8442	**18**	26	22	23	23	17	15	11	13	11	12
50-59	7547	**12**	18	16	15	14	12	10	8	9	5	7
60-64	3933	**8**	15	10	8	11	5	6	8	8	3	5
Skintype	*p<0.001*		*p<0.001*	*0.003*	*0.015*	*0.154*	*0.002*	*p<0.001*	*0.123*	*0.006*	*0.068*	*0.025*
I	4550	**13**	23	19	20	18	9	6	8	8	6	10
II	19316	**18**	24	25	26	22	16	13	12	12	9	10
III	12203	**19**	30	23	27	22	16	15	11	13	11	13
IV	735	**23**	30	33	25	27	13	21	19	17	14	16
Region	*p<0.001*		*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*0.007*	*0.008*	*p<0.001*	*p<0.001*	*0.176*	*0.487*
Capital	13065	**15**	20	21	23	18	12	10	6	8	7	10
Zealand	4680	**16**	24	26	18	21	15	13	14	12	10	10
Northern Jutland	7028	**21**	35	29	29	25	17	16	14	16	10	13
Central Jutland	8086	**19**	30	29	28	26	16	15	12	12	10	10
Southern Denmark	3749	**18**	30	20	29	22	17	13	13	13	11	12
Education	*p<0.001*		*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*0.009*	*0.024*	*0.359*	*0.067*	*0.017*
< 10 years	9372	**17**	32	29	24	20	12	12	10	11	6	9
10-12 years	14881	**20**	30	28	29	26	18	15	10	13	11	12
>12 years	12909	**15**	21	20	20	16	13	11	14	11	9	10
Sunbathe	*p<0.001*		*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*
Yes	24350	**24**	33	32	34	29	20	18	15	15	12	15
No	13416	**7**	7	11	9	8	6	5	5	6	3	3
Have children	*p<0.001*		0.198	0.028	0.233	0.596	0.240	0.087	0.414	0.320	0.771	0.155
Yes	12527	**18**	27	25	24	21	14	14	12	11	9	12
No	25239	**17**	25	23	26	22	16	12	11	12	9	10

p-values are for χ^2-test between observed and expected (average) factor levels.

Supplemental table S1b Percentage of sunbed use (ever use) by demographic characteristics and year of measurement in cross-sectional surveys in Denmark 2007-2015 of 37.766 Danes**.**

Characteristic **(%)** Total (n)	Total (n)	% or mean	March 2007 (%)	August 2007	August 2008	August 2009	August 2010	August 2011	August 2012	August 2013	August 2014	August 2015
Total (n)	37766	**52**	4303	4451	4277	4186	4156	4130	2195	4022	2047	3999
Gender	*p<0.001*		*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*
Male	18437	**39**	40	36	40	43	39	40	38	38	38	35
Female	19300	**64**	68	66	72	70	61	62	60	57	59	58
Agegroup	*p<0.001*		*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*0.008*	*p<0.001*	*p<0.001*	*p<0.001*
15-19	3417	**40**	57	57	61	51	34	28	22	23	27	22
20-29	6017	**60**	79	78	70	67	59	59	56	53	51	44
30-39	7409	**68**	77	74	71	69	66	64	65	60	62	62
40-49	8442	**59**	61	57	58	59	59	58	56	57	61	60
50-59	7547	**41**	44	40	38	45	42	44	42	40	41	40
60-64	3933	**32**	37	31	35	36	29	33	26	33	26	33
Skintype	*p<0.001*		*p<0.001*	*0.003*	*0.015*	*0.154*	*0.002*	*p<0.001*	*0.123*	*0.006*	*0.068*	*0.025*
I	4550	**52**	60	54	55	57	51	50	53	48	51	48
II	19316	**54**	56	56	58	60	55	54	50	51	52	47
III	12203	**49**	55	49	53	52	49	48	47	44	41	47
IV	735	**49**	51	53	51	53	40	47	44	46	51	46
Region	*p<0.001*		*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*0.007*	*0.008*	*p<0.001*	*p<0.001*	*0.176*	*0.487*
Capital	13065	**51**	54	52	55	55	51	51	48	47	46	47
Zealand	4680	**49**	51	54	50	54	48	48	48	46	44	43
Northern Jutland	7028	**55**	59	56	61	62	50	51	52	52	54	51
Central Jutland	8086	**53**	60	55	56	60	55	52	51	48	48	45
Southern Denmark	3749	**51**	56	50	58	51	53	50	48	48	51	47
Education	*p<0.001*		*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*0.009*	*0.024*	*0.359*	*0.067*	*0.017*
< 10 years	9372	**44**	48	44	49	49	42	41	34	40	31	41
10-12 years	14881	**56**	61	57	60	62	57	56	52	48	44	47
>12 years	12909	**54**	55	53	56	57	52	54	59	53	52	50
Sunbathe	*p<0.001*		*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*
Yes	24350	**61**	65	63	67	66	61	61	58	55	55	56
No	13416	**35**	31	36	35	37	35	36	35	34	36	31
Have children	*p<0.001*		0.198	0.028	0.233	0.596	0.240	0.087	0.414	0.320	0.771	0.155
Yes	12527	**60**	65	63	62	63	62	59	62	51	49	55
No	25239	**48**	51	47	52	53	47	47	44	46	48	43

p-values are for χ^2-test between observed and expected (average) factor levels.

Supplemental table S2 Logistic regression analysis of sunbed use (past 12 months) in Denmark 2007-2015 by demographic factors and annual percentage decrease in sunbed use overall and by factor levels.

Characteristic **(%)** Total (n)	Total (n)	% or mean	Crude OR (95 C.I.)	[a)]Adjusted OR (95 C.I.)	[b)]Adjusted OR (95 C.I.)	Sunbed use annual percentage decrease	Sunbed use change by annual measurement (adjusted)
Total (n)	37562	18	34616	34616	34616	0.85 % (0.84-0.86)	**0.82 % (0.81-0.84)**
Gender			*p<0.001*	*p<0.001*	*p<0.001*		
Male	18325	13	1 (ref)	1 (ref)	1 (ref)	0.90 % (0.88-0.91)	
Female	19237	22	1.96 (1.85-2.08)	2.12 (2.00-2.25)	1.74 (1.63-1.85)	0.83 % (0.82-0.84)	
Agegroup			*p<0.001*	*p<0.001*	*p<0.001*		
15-19	3383	27	4.00 (3.48-4.60)	4.15 (3.59-4.80)	3.41 (2.94-3.96)	0.76 % (0.74-0.79)	
20-29	5970	25	3.52 (3.09-4.00)	4.21 (3.67-4.83)	4.21 (3.66-4.85)	0.80 % (0.78-0.82)	
30-39	7369	19	2.55 (2.24-2.90)	3.21 (2.79-3.70)	3.19 (2.77-3.69)	0.82 % (0.81-0.84)	
40-49	8419	18	2.39 (2.10-2.71)	2.84 (2.47-3.25)	2.67 (2.32-3.07)	0.89 % (0.87-0.91)	
50-59	7529	12	1.48 (1.30-1.70)	1.57 (1.37-1.87)	1.45 (1.26-1.66)	0.88 % (0.86-0.91)	
60-64	3922	8	1 (ref)	1 (ref)	1 (ref)	0.88 % (0.84-0.91)	
Skintype			*p<0.001*	*p<0.001*	*p<0.001*		
I	4534	13	0.45 (0.37-0.54)	0.32 (0.26-0.39)	0.43 (0.35-0.53)	0.85 % (0.82-0.88)	
II	19252	18	0.67 (0.56-0.80)	0.59 (0.49-0.71)	0.64 (0.53-0.78)	0.85 % (0.84-0.87)	
III	12141	19	0.74 (0.62-0.89)	0.74 (0.62-0.90)	0.80 (0.66-0.98)	0.85 % (0.84-0.87)	
IV	733	23	1 (ref)	1 (ref)	1 (ref)	0.86 % (0.81-0.92)	
Region			*p<0.001*	*p<0.001*	*p<0.001*		
Capital	12998	15	1 (ref)	1 (ref)	1 (ref)	0.85 % (0.84-0.87)	
Zealand	4652	16	1.10 (1.01-1.21)	1.15 (1.04-1.27)	1.32 (1.20-1.46)	0.87 % (0.84-0.89)	
Northern Jutland	3730	21	1.54 (1.40-1.69)	1.60 (1.45-1.76)	1.73 (1.57-1.91)	0.84 % (0.81-0.86)	
Central Jutland	8042	19	1.36 (1.26-1.47)	1.40 (1.30-1.51)	1.51 (1.40-1.64)	0.83 % (0.81-0.85)	
Southern Denmark	6985	18	1.25 (1.16-1.36)	1.30 (1.20-1.41)	1.44 (1.32-1.57)	0.86 % (0.84-0.88)	
Education			*p<0.001*	*p<0.001*	*p<0.001*		
< 10 years	9313	17	1.13 (1.05-1.22)	1.25 (1.15-1.36)	1.37 (1.26-1.49)	0.80 % (0.78-0.82)	
10-12 years	7130	20	1.40 (1.23-1.40)	1.25 (1.17-1.34)	1.37 (1.28-1.47)	0.84 % (0.83-0.86)	
>12 years	7682	18	1 (ref)	1 (ref)	1 (ref)	0.88 % (0.86-0.89)	
Sunbathe			*p<0.001*	N.A	*p<0.001*		
Yes	24240	24	4.16 (3.85-4.49)		3.47 (3.20-3.77)	0.85 % (0.84-0.86)	
No	13322	7	1 (ref)		1 (ref)	0.88 % (0.85-0.90)	
Have children<18 in household			N.S.	*p<0.001*	*p<0.001*		
Yes	12461	18	1.01 (0.96-1.07)	0.87 (0.81-0.93)	0.94 (0.89-0.99)	0.86 % (0.85-0.88)	
No	25101	17	1 (ref)	1 (ref)	1 (ref)	0.85 % (0.84-0.86)	
Temperature (Degree celsious)			*p<0.001*	N.A	*p<0.001*		
			1.29 (1.26-1.33)		1.51 (1.44-1.59)		
Sunhours (/100/summer)			*p<0.001*	N.A	*p=0.023*		
			1.14 (1.09-1.19)		1.25 (1.05-1.49)		
Days with rain /month			*p<0.001*	N.A	*p<0.001*		
			0.96 (0.95-0.97)		1.07 (1.05-1.09)		

Odds ratios and confidence intervals (CIs). a) Model adjusted for gender, age, education, skin type, have children and region. b) Model additionally adjusted for sunbathing and weather indicators

STROBE Statement—checklist of items that should be included in reports of observational studies
Items are present at PageX and LineY: PXLY

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract: P3L4
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found P3
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported P4L3-P4L25
Objectives	3	State specific objectives, including any prespecified hypotheses P4L47-P5L2
Methods		
Study design	4	Present key elements of study design early in the paper P5L6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection P5L12-23
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants P5L12-23
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable P5L12-P5L36
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group P5L38-P6L8
Bias	9	Describe any efforts to address potential sources of bias P5L12-36
Study size	10	Explain how the study size was arrived at P5L12-23 and table1
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why P5L38-P6L8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding P5L38-P6L8
		(*b*) Describe any methods used to examine subgroups and interactions P5L12-P6L8
		(*c*) Explain how missing data were addressed Not relevant due to sampling methodology
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy P5L7-P6L8
		(*e*) Describe any sensitivity analyses P7L25-27

Continued on next page

Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed P7L31-43, Table 1
		(b) Give reasons for non-participation at each stage P7L31-43, Table 1
		(c) Consider use of a flow diagram Not relevant
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders P7L31-43, Table 1-2
		(b) Indicate number of participants with missing data for each variable of interest Table 1
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures Table 2
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included P8L12-39, Table 3, Figure 3
		(*b*) Report category boundaries when continuous variables were categorized Table 3
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period P8L12-39, Table 2-3, Figure 3
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses P8L34-39, Tabel 3
Discussion		
Key results	18	Summarise key results with reference to study objectives P9L1-6
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias P9L8-28
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence P9L30-37
Generalisability	21	Discuss the generalisability (external validity) of the study results P9L39-P10L12
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based P10L27

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Repeated Cross-Sectional Surveys of Sunbed Use 2007-15 and Skin Cancer Projections of Campaign Results 2007-40 in the Danish Population

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Repeated Cross-Sectional Surveys of Sunbed Use 2007-15 and Skin Cancer Projections of Campaign Results 2007-40 in the Danish Population

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Statement of independence of researchers from funders:

The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Keywords: Skin Cancer, Prevention, Malignant Melanoma Projections, Campaign, Ultraviolet Radiation, Questionnaire

Ethical approval was not required

Transparency declaration:

Brian Køster affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

Abstract

Objective: To evaluate the effect of the Danish Sun Safety Campaign 2007-15 on the prevalence of sunbed use and to model future effects on the skin cancer incidences 2007-40.

Design: The study is a repeated, cross-sectional design.

Setting: Exposure to ultraviolet radiation is the main risk factor for skin cancer. Denmark has the highest prevalence of sunbed use reported and one of the highest incidence of skin cancer worldwide.

Participants: During 2007-15, survey data was collected for 37 766 Danes, representative for the Danish population in regards to age, gender and region.

Interventions: In 2007, an ongoing long-term anti-sunbed campaign was launched in Denmark.

Primary and secondary outcome measures: Sunbed use was evaluated by annual cross-sectional surveys. Skin cancer incidence was modelled in the Prevent program, using population projections, historic cancer incidence, sunbed use exposure and relative risk of sunbed use on melanoma.

Results: The prevalence of recent sunbed use in Denmark was reduced from 32% and 18% to 13% and 8 % for women and men, respectively. The campaigns results during 2007-15 is estimated to reduce the number of skin cancer cases with more than 5 000 (746 MM, 1562 SCC, 2673 BCC) totally during 2007-40. Keeping the 2015-level of sunbed use constant by a continued campaign pressure or introduction of structural interventions would potentially prevent more than 750 skin cancer cases annually in 2040 and 16 000 skin cancer cases in total during 2007-40.

Conclusion: We have shown the value of prevention and the value of long term planning in prevention campaigning. Sunbed use was reduced significantly during 2007-15 and further reductions are possible by structural interventions. Consequently, significant fewer skin cancer cases are anticipated 2007-40. The Danish parliament has population support to enforce structural interventions to avoid a large burden of this disease.

Strength and Limitations

- Long term funding and planning secured the continuity in this study, comparability of data over time and the achievements of results
- High awareness created by the campaign could cause e.g. political correctness bias or selection bias
- Projection models can be influenced by changes in improved diagnostics, equipment, change in strength of UV spectrum or output in sunbeds or other changes in population UV-exposure

Introduction

Exposure to ultraviolet radiation (UVR) is the main modifiable risk factor for keratinocyte skin cancers (SCC and BCC) and malignant melanoma (MM) skin cancer (1, 2). Intermittent exposure to UVR from the sun and sunbeds, and sunburn history, are important factors in the etiology of skin cancer (3, 4). In Denmark, the MM incidence (world standardized rate per 100 000) for men and women increased from 1.4 and 1.9 in 1949–1953 to 21.4 and 26.7 in 2010–2014, respectively (5). The development is or was similar in most Caucasian populations, including in Northern European countries (6). Similarly, keratinocyte skin cancer incidence increased manifold in the same period. Presumably because of improved primary and secondary prevention, improved diagnostics (7, 8) and change in sun exposure patterns including increased number of Danes travelling abroad since the 1960's and the introduction and spread of sunbed facilities in the 1980's. Half of the Danish population travel to sunny destinations each year (9, 10), approximately 60 % have ever used a sunbed (11) and 40 % were sunburnt annually (9, 12).

In 2009, the International Agency for Research on Cancer classified ultraviolet- emitting tanning devices as 'carcinogenic to humans' with respect to MM (13). (4, 14-17). The increased risk of MM was especially high among sunbed users younger than 30-35 years, and more than 75 % of cases diagnosed in this young age was caused by sunbed use. Additionally, sunbed use was shown to increase the risk of MM without the presence of sunburn (15, 17). Boniol et al. summarized the risk of MM from sunbed use in a systematic review to be 1.2 for ever-use of sunbed and 1.59 for sunbed use initiated before the age of 35. Furthermore, a dose response relationship was established between frequency of sunbed use and MM with an increased risk of 2 % for each extra annual session (18). The increased risk of developing basal cell carcinoma and squamous cell carcinoma from sunbed use was summarized by Wehner et al. (19) to 1.29 and 1.67, respectively. Sunbed use is highly prevalent in Denmark, especially in younger age groups and more than half of those recalling their age of initiation of sunbed use reported to have started before age 18 (20, 21). Sunbed use was estimated to be responsible for 13 % and 8 % of MM cases in Denmark in women and men (18).

Campaign content

In May 2007, an anti-sunbed campaign was launched, with young people aged 15–25 as the primary target. The campaign was based mainly on social media and also magazines and radio, the traditional youth targeted media. The campaign was very successful, with viral dissemination of video clips, music videos and other materials that made links between sunbed use, negative cosmetic effects and skin damage and educational programs including a pocket movie competition in 7th graders making them ambassadors for anti-sunbed campaigning.

The public activities included lobbying at national and local government levels and a public campaign program. The lobbying focused on legal prohibition of sunbed use for children under 18 years of age and the removal of sunbeds from, e.g. local sport facilities and pools under local government administration. In summer 2009, politicians spoke out in favor of legal restriction of sunbed use by children under 18 years of age. During spring and summer of 2009, some local governments started removing sunbeds from public facilities, and in 2017, the majority of local governments have removed sunbeds from their buildings. Only six out of 98 local governments still have sunbeds in their buildings and in two of those age restrictions (<18 y) have been implemented. However, the majority of sunbed operators in Denmark are commercial and not influenced by these restrictions. The campaign generated press coverage and political debate, which raised public awareness of the health risks associated with sunbed use, included more than 2700 press clips on sunbed topics during the period of the study.

We studied the development in sunbed use in Denmark after the start of a 10-year national sun protection campaign in March 2007. The aims of this study is 1) to show the possible effects of the Danish Sun Safety

Campaign on prevalence of sunbed use and 2) to estimate potential reductions in future skin cancer incidence by the campaign.

Materials and Methods

Overview

We estimated the effect of the Danish Sun Safety Campaign during 2007-15 in terms of annual reduction in the fraction of ever users of sunbed. We modelled projections of future cancer incidence, introducing the effects of the campaign and compared with status quo using realistic estimates of relative risks in the intervention scenarios to obtain an indication of the long-term impact of the campaign interventions on cancer incidence.

Questionnaire and confounding

During 2007-2015, a question on frequency of sunbed use was included in the annual population-based questionnaires on exposure to UV radiation and behavior and attitude towards UV exposure. In total, 37 766 Danes answered the 75-item questionnaire. Data was collected by computer assisted web interview (CAWI) by Epinion (2007 and 2014-15) and Userneeds (2008-13). Data was collected as representative for the Danish population by gender, age, region and education. The education variable included 7-10 options during the period and it was condensed into the three categories as shown in table 1. For the initial measurements in 2007, there was no higher age limit and persons 65 and older were categorized as missing to be able to compare to following measurements. Since 2009, a limited number of internet panels were available, which were able to provide the respondent structure requested. To avoid measuring only effect in the panel and not in the population, it was a requirement that maximum 25 % of the participants were allowed to participate in the survey the following year, because answering a questionnaire could influence the behavior. Detailed data sampling strategies are available in annual survey reports on skrunedforsolen.dk (22). Exposure to artificial UVR was determined by the question: ('How often did you use a sunbed within the past 12 months?': 'More than once a week, Once a week, More than once a month, Once a month, Fewer than four times a year, Not within the past twelve months, Never'); The questionnaire also elicited information on behavior with respect to exposure to natural UVR; these results will be reported separately. The question about sunbathing was included in the analysis to distinguish between intentional and non-intentional tanning (1). As data collection and panel composition evolved as well differences exist between years. Age was included in all analysis as five or 10-year age groups. Teenagers were kept as '15-19 years' as their behavior was shown to differ from that of the adult population (23, 24). Skin types were determined from self-assessed tan and sunburn reactions, according to Fitzpatrick skin type I (never tan, always burn) to skin type IV-VI (always tan, never burn)(25).

The accumulated sun hours and average temperature of June and July was included in the regression analysis as Danes could be more prone to use sunbed when the weather conditions makes outdoor sunbathing impossible and significant variation in weather measures occurred during the period analyzed.

Patient involvement

The Danish Sun Safety Campaign has continuously used information from for example interviews and focus groups with patients, at-risk groups and lay people in an iterative setup to improve campaign elements as well as annual evaluations of the campaign. Recruitment is described above and dissemination of results will be by scientific publication, national press as well as patient organization newsletters from the Danish Cancer Society.

Analysis

Answers to sunbed use were grouped into 'recent users' and 'non-recent users' and 'ever users' and 'never users', respectively. Recent use was defined as use within the past 12 months. Similarly, ever-use of sunbed was defined as belonging to all categories except the 'never' category. Recent use was modelled to describe immediate changes in sunbed use according to aim 1 and ever-use was modelled for use in the cancer projections for aim 2. The homogeneity of respectively recent and ever sunbed use over time of survey and demographic variables was examined. The outcome 'sunbed use, yes / no' was analysed using logistic regression. The factors included in the model, as categorical variables, were gender, age, education, skin type, having children below age 18 in household and region. Factors with a statistically significant different distribution were included as possible explanations. Adjusted odds ratios (ORs) and 95% confidence intervals (CIs) were calculated. The *p*-values from the logistic regression analysis refer to either tests for variation between the factor levels by time (year) or trend as stated for the relevant analysis. For all tests, P values < 0.05 were considered statistically significant. The procedure logistic in SAS version 9.3 (SAS Institute, Cary, NC, USA) was used for the analyses.

The prevent model

Projection of future incidence was estimated using Prevent (26, 27). This program was adapted for the Eurocadet project to model future cancer incidence by implementation of lifestyle preventive strategies. Prevent calculated the percentages of potentially prevented cases under the scenario of interest as compared to the status quo scenario. If the scenario of interest is no exposure or exposure with minimum impact on risk, this percentage is interpretable as the population attributable fraction (PAF) of sunbed use experience, respectively, on skin cancer (MM, SCC, BCC) incidence by the year 2040: they represent the numbers of cases that would be prevented had the population not used sunbed and therefore the fraction of MM, SCC and BCC cases attributable to these risk factors. Three types of data are needed to run the model; 1) demographic data (current and projected population sizes by age and sex), 2) risk factor-related data (prevalence, changes in prevalence as a result of interventions and risk estimates) and 3) disease incidence data (cancer rates and estimated annual percentage change to account for trends in disease incidence that are not associated with modelled risk factor data). The projected numbers of new cancer cases were computed based on the demographic data and under different scenarios of changes in the prevalence of risk factors. Results are projected rates and numbers with and without modelled interventions by risk factor prevalence. The model is summarized in figure 1.

Exposure: Sunbed use

The prevalence of sunbed use was derived from sun behavior questionnaires of The Danish Sun Safety Campaign as described above. The campaign was the only initiative in Denmark collecting data on UVR exposure continuously since 2007 (9, 12, 28-31). In the Prevent model, sunbed use was included as ever/never use. The change in prevalence of sunburn applied in the population projections was from logistic regression analysis.

Incidence data

National incidence rates for melanoma and keratinocyte skin cancer (ICD-10 code: C43 and C44) by sex and 5-year age groups were retrieved from NORDCAN (5). The estimated annual percentage change (EAPC) for men and women for the past 25 years, respectively, was 6.4 % and 10.9 % increase for SCC, 5.4% and 7.4 % for BCC and 4.4 % and 4.5 % for melanoma (5). We chose to use a uniform conservative 4% increase in all skin cancer rates for men and women for the modelling. The EAPC was applied for the first 15 years after

which it remained constant at this level. For sensitivity analysis, we applied an EAPC respectively of 0 and 30 years. The registration of keratinocyte skin cancer C44 is probably more complete in Denmark than in most other countries. Since 2004 the cancer registration has been made by a linkage between the national hospital register, the pathology register, and the cause of death register. For both melanoma skin cancer, C43, and C44, keratinocyte skin cancer, divided into BCC and other keratinocyte skin cancers, mainly SCC, registrations are also included based on a registration in the pathology register alone from 2004 and on.

Population projections

From Statistics Denmark we obtained the size of the population on January 1st, of the corresponding period of the latest available incidence data by 1-year age category and sex as well as forecasted population sizes for each year up to 2040 by 5-year age categories and sex, using the medium national growth estimates.

Effect of sunbed use on the incidence of melanoma skin cancer.

Relative risks for sunbed use on the risk of MM and keratinocyte cancers were derived from the largest meta-analysis', on the subject, established by respectively Boniol et al. and Wehner et al. MM: RR= 1.2 for >35-year-olds and RR = 1.59 for < 35-year-olds and RR for SCC and BCC of 1.67 and 1.29 respectively. (18, 32). These findings were used as the relative risks and risk functions in our modelling (fig. 1). The relative risks and risk functions were assumed equal for all age groups within age bands and included in the study, and across time. The effect of a risk factor exposure on cancer incidence has a latency time. Prevent accommodates this through two time lags: 1) the time that the risk remains unchanged after a decline in risk factor exposure (LAT) and 2) the period during which the changes in risk factor exposure gradually affect the risk of cancer, eventually reaching risk levels of the non-exposed (LAG)(26). Thus, assuming that sunbed users who quit sunbed use following the campaign after a total of (LAT + LAG) years are no longer at increased risk of skin cancer. For this study, we used for sunbed use a LAT of 2 years and a LAG of 5 years for MM and respectively 2 and 8 years for keratinocyte cancers. LAG was modelled as a linearly declining risk. LAT and LAG periods for sunbed use on risk of skin cancers has not been estimated precisely. Pil et al. used an induction period of 20 years, however we chose shorter time periods for MM from the knowledge of intermittent exposure pathway (1) and the experiences from Iceland (33) and sunbed use in young people (14). In Iceland both a drastic increase and following decrease in melanoma incidence was observed within a 10-year period preceded by complimentary delayed increase and decrease, respectively, in the number of available sunbed salons. The MM incidence change was primarily driven by people below 50 and trunk site melanomas, which are characteristic for intermittent/sunbed exposure.

We have modelled the development in future skin cancer Incidence in Denmark in three scenarios. We have used the reductions in sunbed use during 2007-15 to model MM Incidence in 2007-40.

- Scenario 1) We assume the campaign is discontinued after 2015 and that the rate of sunbed use remains constant afterwards (Irreversible campaign effect)
- Scenario 2) Similar to scenario 1 except, we have modelled a conservative 'spring effect' where the prevalence of sunbed use returns to pre campaign level in the inverse rate as it was reduced 2015-2023 (reversible campaign effect)
- Scenario 3) The expected trend if prevalence of sunbed use is unchanged (trend/no campaign effect)

We have also applied sensitivity analyses to the conservative scenario 2. We have used the applied EAPC for 0, respectively 30 years instead of 15. We have applied a combined LAT+LAG time of either zero or twice the time, of the main scenario.

Results

Table 1 shows the distribution of demographic characteristics from annual data collections during 2007-15. Answers were collected from more than 4000 persons/survey, except for 2012 and 2014 were 2000 persons/survey was settled for due to challenges with data collection of certain groups, especially young (15-19 y) men. For all included variables, we found significant variation over years. Only 2007 data collections differed for gender, after which sampling methods were optimized. In 2007 there was no higher limit for age, however in this analysis persons older than 65 were excluded, which lead to differences in the distribution of age compared to 2008-15. There was more people characterized with paler skin types in 2013-15. Region and education was not used in the sampling all years, which mean that e.g. august 2007 data are overrepresented by persons from region capital. Education was differently distributed in panels and in panel characterizations of education between years. Persons who reported sunbathing declined during the campaign period. Persons having children 18 or younger staying at home also varied. Weather varied randomly for the variables mean temperature, mean monthly number of sunhours and mean monthly days with rain.

Supplemental table S1a and b shows the detailed distribution of sunbed use, recent and ever-use respectively. In all the annual surveys, there are differences for all included variables except having children. In general, more women used sunbed and sunbed use decreased by age. More persons with dark skin types used sunbed and sunbed use was more prevalent in Northern Jutland and the less prevalent in region Capital. Fewer persons with more than 12 years of education used sunbed, while more persons who sunbathed also use sunbeds.

Figure 2a and b shows the adjusted odds-ratio (OR) and 95 C.I: of the development in sunbed use (recent and ever-use respectively) adjusted for gender, age, education, region and skin type, with the March 2007 measurement as reference point. The decrease in sunbed use was largest in the beginning of the campaign period and until about 2011/12, where the decrease leveled. In 2015, the OR for sunbed use was approximately 0.3 compared to the pre-campaign measurement in March 2007.

Table 2 (ever-use) and supplemental table S2 (recent use) shows the logistic regression analysis of the sunbed use in Denmark by demographic factors in the left part of the table and in the right part is shown the annual percentage change in sunbed use per year. Age and skin type are the variables most influential on sunbed use. We have shown the crude OR (95 C.I.) and a model adjusted for gender, age, skin type, region, education and having children below 18 in household. Due to the large differences in education in our analysis of the development of sunbed use, we also tried to exclude education, but that did not change the estimates significantly. In addition, we examined the influence by weather parameters in a model additionally adjusted for temperature, number of sunhours and days with rain. We found that increasing temperature, number of sun hours and number of days with rain was associated with increased sunbed use. In the right side of tables 2 and S2 is shown the crude reduction by annual measurement. Females reduced their recent sunbed use more than men and young persons more than older persons, especially the 15-29-year-olds. There was no significant differences in reduction by skin type, region, education, sunbathing or among people with or without children. Overall, the adjusted analysis for ever-use of sunbed showed an annual reduction of more than 3 % per year in the campaign period. For recent sunbed use the annual reduction was 4 % per year.

The prevalence of sunbed use influence on future skin cancer incidence

In figure 3a-c, we have modelled the development in the number of future MM, SCC and BCC Incidence cases according to scenarios 1-3 in Denmark. The effect of the campaign results in a reduction of 103 MM,

271 SCC and 387 BCC skin cancer cases pr. year in 2040 and in total 2443 MM, 5383 SCC and 8437 BCC cases during 2007-40, while if the effect of the campaign is reversed to pre-campaign level there will be no change in annual number of skin cancer cases in 2040 but a total reduction of 746 MM, 1562 SCC and 2673 BCC cases during 2007-40. The results of the skin cancer reductions projections including relative reductions are summarized in table 3. The table also includes the projections for the sensitivity analysis for scenario 2 where EAPC and LAT+LAG were examined. There was a minimum and a maximum of 423 and 869 fewer MM cases, respectively, during 2007-40. Minimum and maximum of all skin cancer types were 6208 and 11 972 fewer cases totally during 2007-40. The relative decrease is larger for irreversible campaign effects compared to reversible. The sensitivity analysis variations of scenario 2 were robust to changes in cancer incidence and time to effect.

Discussion

We have shown that the Danish Sun Safety Campaign reduced the recent sunbed use during 2007-15, from 32 % and 18 % to 13 % and 8 % for women and men, respectively. The OR for recent sunbed use in 2015 compared to the pre-campaign level was 0.3. We have modelled these results in respect to future skin cancer incidences and expect more than 750 fewer cancer cases annually in 2040 and more than 16.000 fewer cases totally until 2040, as the campaign is still ongoing. Had the campaign been terminated after 2015, it may not influence the annual number of skin cancers in 2040, however during 2007-40 still more than 5 000 skin cancer (MM, SCC and BCC) cases would have been avoided.

Strengths and limitations

The unique strengths of this study is the possibility of long time planning, securing the continuity in the campaign including comparable wordings in the questionnaires and personnel to secure comparable evaluations over the entire period as well as long term funding has made the high continuous campaign pressure possible.

There is a risk that the high awareness created by the campaign could have caused political correctness bias meaning that e.g. persons would have falsely stated no to sunbed use in questionnaires. Similarly selection bias may have occurred, e.g. if sunbed users were less prone to participate in surveys of this subject.

A prognosis of the cancer incidence in absolute numbers is difficult to provide as, there are unknown indicators, which we were not able to include in the model like improved diagnostics, equipment, change in strength of UV spectrum or output in sunbeds (7, 34) or other changes in UV-exposure. As we have used the difference between two cancer incidence rates this had minor influence on the results. The prevent model primarily gives useful measures of the influence of change in use of sunbeds. The model accuracy is as good as the quality of the data input and dependent on the assumptions applied for the scenarios. Exact LAT and LAG times are not determined; however, varying LAT+LAG times were included in the sensitivity analysis and their relative estimates were within a reasonable range. Model based results should be interpreted with caution and mentioning of limitations.

The number of skin cancer cases in the years passed is different from the actual incidence development because it is influenced by factors not included. About year 2002-04 the dermatoscope was introduced among dermatologists in Denmark, which probably increased the rate of detection (7) for a while. In the following period a plateau is seen from around 2011 (5). The decreasing incidence rate is likely to be a consequence of the earlier detection/treatment, an effect also seen in various screening programs. While the increasing skin cancer incidences raised the media awareness of the disease in the ‘90s, in 2007, the

multi component Intervention of the Danish Sun Safety Campaign increased this awareness manifold. The increased awareness may have lead to an increase in mole check by the general physician, which could have increased the number of diagnoses; however we were not able to measure this.

Reduction in sunbed use

Denmark had one of the highest reported frequencies of sunbed use in the world before the Danish Sun Safety Campaign was launched. The largest reductions in sunbed use occurred among the youngest age groups and among females, which had the highest prevalence of sunbed use and were the main targets of the campaign. Even though large reductions in sunbed use occurred, the prevalence of sunbed use in Denmark is now just comparable to other European countries, e.g. 14 % within the past year in Germany in 2012 (35). Concerning campaign efficiency, there have been anti-sunbed campaigns in e.g. UK, Canada, US and Australia, which have also shown reductions, however our baseline use are not similar and comparable. The past years of the reductions in sunbed use has leveled of perhaps as a consequence of a changed focus of the Danish Sun Safety Campaign towards sunny holidays or perhaps the remaining sunbed users are less perceptible of risk communication.

Consequences and recommendations

Pil et al. (36) have previously modelled the effect of various scenarios thought to prevent skin cancer. Our results are based on an actual intervention with measurable results of the exposure; therefore, our modelling results of the future cancer incidence are a realistic prognosis of the incidence change. Likewise, we have shown the importance of a continued campaign pressure to achieve these goals (difference between model 1 and 2).

The WHO suggests countries bans sunbeds or alternatively restrict (staff supervision, age limit, high-risk individuals), manage (license, radiation output and time limits, staff training, tax) and inform (health risks, display warning, ban marketing) to protect their populations (37). In 2017, the majority of countries in Western Europe and the majority of American states have introduced age limits for sunbed use to protect children, and states with age limits succeeded in reducing the prevalence of sunbed use (38). Furthermore, Australia and Brazil has completely banned sunbed use to protect their populations against the detrimental effects of sunbed use on human health and to reduce government spending related to skin cancer diagnostics and treatment (39). Belgium is to our knowledge the first European country to recommend a ban against sunbed use (40), while Denmark is now one of few remaining western European countries without an age limit to protect children (41).

Emphasizing the health potential of the achieved results, we hope to motivate government administration to implement structural interventions to reduce the sunbed use in Denmark as well as in countries with similar problems as in Denmark. We specifically address the need for a revision of the Danish sunbed legislation adopted in 2014.

Conclusion

The Danish Sun Safety Campaign has significantly reduced the sunbed use in Denmark since 2007. Several legislative restrictive measures exists which would be beneficial to introduce to reduce the sunbed use further at the current stage and to avoid that the sunbed use increases again if campaigning is not available. Because of the campaign, we expect fewer skin cancer cases in Denmark in the future. Danish

politicians have the opportunity, supported by the population, to reduce the skin cancer incidences further and thereby to reduce the future costs of skin cancer.

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Conflicts of interest

The authors have declared that no competing interests exist. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Data sharing: Full dataset available from the corresponding author.

Authorship Contribution Statement

BK, MM, TA, GE and PD have contributed to conceptualization and design of the study, analysis and interpretation of data, critical revision of the manuscript and final approval of the manuscript. BK drafted the manuscript.

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Table 1. Distribution of demographic characteristics in cross-sectional surveys on UV-exposure 2007-2015 of 37 766 Danes.

Characteristic **(%)**	Total (n)	% or mean	March 2007 (%)	August 2007	August 2008	August 2009	August 2010	August 2011	August 2012	August 2013	August 2014	August 2015
Total (n)	37766	**100**	4303	4451	4277	4186	4156	4130	2195	4022	2047	3999
Gender	*p<0.001*											
Male	18437	**49**	44	44	50	50	50	50	50	50	50	50
Female	19300	**51**	56	56	50	50	50	50	50	50	50	50
Agegroup	*p<0.001*											
15-19	3417	**9**	8	8	10	9	10	9	9	10	10	10
20-29	6017	**16**	9	8	18	17	17	17	17	19	19	20
30-39	7409	**20**	20	20	16	21	21	21	21	19	19	18
40-49	8442	**23**	21	23	23	22	22	22	22	23	22	22
50-59	7547	**20**	20	19	24	20	20	20	20	19	18	18
60-64	3933	**10**	11	10	8	11	10	10	10	11	12	12
missing	1001	**3**	11	11	0	0	0	0	0	0	0	0
Skintype	*p<0.001*											
I	4550	**12**	12	10	11	10	10	11	11	16	15	15
II	19316	**51**	51	51	52	52	53	54	51	48	50	50
III	12203	**32**	34	35	33	34	34	32	33	29	31	28
IV-IV	735	**2**	3	3	2	2	2	1	2	2	2	2
missing	962	**1**	1	1	1	1	1	1	1	1	1	1
Region	*p<0.001*											
Capital	13065	**35**	39	46	33	32	32	32	31	32	32	32
Zealand	4680	**12**	11	9	13	12	12	12	15	14	14	14
Northern Jutland	7028	**10**	10	9	10	11	10	10	10	10	10	10
Central Jutland	8086	**21**	21	18	21	22	21	22	23	23	21	23
Southern Denmark	3749	**19**	16	14	18	18	19	18	22	21	23	21
Missing	1158	**3**	3	3	5	5	6	5	0	0	0	0
Education	*p<0.001*											
< 10 years	9372	**25**	18	16	31	32	28	29	28	28	8	24
10-12 years	14881	**39**	29	28	44	45	49	49	42	40	27	42
>12 years	12909	**34**	54	55	25	22	22	21	28	31	64	32
Missing/unspecified	604	**2**	1	1	2	2	2	2	2	1	1	2
Sunbathe	*p<0.001*											
Yes	24350	**64**	72	61	65	67	65	61	60	64	66	63
No	13416	**36**	28	39	35	33	35	39	40	36	34	37
Have children	*p<0.001*											
Yes	12527	**33**	35	36	32	33	33	34	25	34	34	32
No	25239	**67**	65	64	68	67	67	66	75	66	66	68
Temperature	*p<0.001*	**15.8**	17.4	15.9	16.3	15.6	16.3	15.8	14.3	15.7	17.2	14.1
Sunhours	*p<0.001*	**241**	285	197	281	250	248	212	203	254	274	210
Days with rain /month	*p<0.001*	**14.4**	8.5	18	13.5	15.2	11.9	15.6	19.4	12.3	13.3	16.2

p-values are for χ^2-test between factor levels and year of measurement. Values are percentage except for weather variables, which are expressed in means.

Table 2 Logistic regression analysis of sunbed use (ever use) in Denmark 2007-2015 by demographic factors and annual percentage decrease in sunbed use overall and by factor levels.

Characteristic **(%)** Total (n)	Total (n)	% or mean	Crude OR (95 C.I.)	[a)]Adjusted OR (95 C.I.)	[b)]Adjusted OR (95 C.I.)	Sunbed use annual change	Sunbed use annual change (adjusted)
Total (n)	37562	18	34616	34616	34616	0.97 (0.97-0.97)	**0.97 (0.97-0.97)**
Gender			*p<0.001*	*p<0.001*	*p<0.001*		
Male	18325	13	1 (ref)	1 (ref)	1 (ref)	0.99 (0.98-1.00)	
Female	19237	22	2.78 (2.66-2.90)	3.02 (2.88-3.16)	2.66 (2.53-2.79)	0.95 (0.95-0.96)	
Agegroup			*p<0.001*	*p<0.001*	*p<0.001*		
15-19	3383	27	1.38 (1.25-1.53)	1.30 (1.17-1.44)	1.03 (0.92-1.15)	0.91 (0.90-0.92)	
20-29	5970	25	3.22 (2.95-3.51)	3.28 (2.99-3.61)	3.06 (2.78-3.37)	0.90 (0.89-0.91)	
30-39	7369	19	4.37 (4.01-4.76)	4.53 (4.11-4.98)	4.78 (4.33-5.28)	0.94 (0.93-0.96)	
40-49	8419	18	2.97 (2.74-3.23)	3.01 (2.75-3.30)	2.95 (2.69-3.24)	1.00 (0.99-1.01)	
50-59	7529	12	1.49 (1.37-1.62)	1.48 (1.36-1.62)	1.45 (1.32-1.58)	1.00 (0.99-1.00)	
60-64	3922	8	1 (ref)	1 (ref)	1 (ref)	0.99 (0.97-1.00)	
Skintype			*p<0.001*	*p<0.001*	*p<0.001*		
I	4534	13	1.08 (0.92-1.28)	0.64 (0.54-0.76)	0.80 (0.66-0.95)	0.97 (0.96-0.98)	
II	19252	18	1.19 (1.02-1.36)	0.92 (0.78-1.09)	0.99 (0.83-1.17)	0.97 (0.97-0.97)	
III	12141	19	0.96 (0.82-1.13)	0.90 (0.76-1.07)	0.93 (0.78-1.10)	0.98 (0.96-0.98)	
IV-VI	733	23	1 (ref)	1 (ref)	1 (ref)	0.98 (0.95-1.00)	
Region			*p<0.001*	*p<0.001*	*p<0.001*		
Capital	12998	15	1 (ref)	1 (ref)	1 (ref)	0.97 (0.97-0.98)	
Zealand	4652	16	0.88 (0.82-0.97)	1.15 (1.04-1.27)	0.99 (0.92-1.07)	0.98 (0.96-0.99)	
Northern Jutland	3730	21	1.17 (1.08-1.26)	0.93 (0.87-1.01)	1.30 (1.20-1.42)	0.97 (0.96-0.98)	
Central Jutland	8042	19	1.08 (1.02-1.14)	1.15 (1.08-1.22)	1.18 (1.10-1.25)	0.96 (0.95-0.97)	
Southern Denmark	6985	18	0.99 (0.94-1.06)	1.08 (1.01-1.15)	1.11 (1.04-1.19)	0.97 (0.97-0.98)	
Education			*p<0.001*	*p<0.001*	*p<0.001*		
< 10 years	9313	17	0.64 (0.61-0.68)	1.01 (0.94-1.07)	1.10 (1.03-1.17)	0.97 (0.96-0.98)	
10-12 years	7130	20	1.04 (0.99-1.09)	1.12 (1.06-1.19)	1.16 (1.10-1.22)	0.95 (0.95-0.96)	
>12 years	7682	18	1 (ref)	1 (ref)	1 (ref)	0.98 (0.98-0.99)	
Sunbathe			*p<0.001*	N.A	*p<0.001*		
Yes	24240	24	4.16 (3.85-4.49)		2.73 (2.59-2.87)	0.96 (0.96-0.97)	
No	13322	7	1 (ref)		1 (ref)	0.99 (0.99-1.00)	
Have children<18 in household			N *p<0.001*	*p=0.030*	*p=0.085*		
Yes	12461	18	1.55 (1.49-1.63)	1.06 (1.01-1.12)	1.05 (0.99-1.11)	0.96 (0.96-0.97)	
No	25101	17	1 (ref)	1 (ref)	1 (ref)	0.98 (0.97-0.98)	
Temperature (Degree celsious)			*p<0.001*	N.A	*p<0.001*		
			1.11 (1.08-1.13)		1.15 (1.11-1.19)		
Sunhours (/100/summer)			*p<0.001*	N.A	*p=0.004*		
			1.13 (1.08-1.19)		1.23 (1.07-1.42)		
Days with rain /month			*p<0.001*	N.A	*p<0.001*		
			0.99 (0.98-0.99)		1.04 (1.03-1.06)		

Odds ratios and confidence intervals (CIs). a) Model adjusted for gender, age, education, skin type, have children and region. b) Model additionally adjusted for sunbathing and weather indicators

Table 3 Projected change in number of skin cancer cases 2007-40 based on modelled scenarios of the change in sunbed use fraction 2007-15 in Denmark compared to trend.

	Projections based on campaign results 2007-15		Sensitivity variations of scenario 2			
Scenario	1 (Irreversible)	2 (Reversible)	EAPC0	EAPC30	LATLAG, Zero	LATLAG, Double
Total MM cases	111.353	111.353	63.104	154.525	111.353	111.353
Total SCC cases	136.999	136.999	83.108	184.766	136.999	136.999
Total BCC cases	414.817	414.817	254.859	547.749	414.817	414.817
ΔTotal MM	2.443 (2,2 %)	746 (0,7 %)	423 (0,7 %)	800 (0,5 %)	584 (0,5 %)	869 (0,8 %)
ΔTotal SCC	5.383 (3,9 %)	1.562 (1,1 %)	945 (1,1 %)	1.705 (0,9 %)	1.220 (0,9 %)	1.885 (1,4 %)
ΔTotal BCC	8.437 (2,0 %)	2.673 (0,6 %)	1.623 (0,6 %)	2.898 (0,5 %)	2.107 (0,5 %)	3.131 (0,8 %)

EAPC0 and EAPC30 corresponds to number of years with the estimated annual percentage change in incidence. Remaining years are constant. Main scenarios apply 15 years EAPC. LATLAG, Zero and Double, respectively is the time from an intervention is applied to the effect of the intervention on the risk factor affects the risk of cancer.

Figure legends

Figure 1

Illustration of data projections and scenarios

Figure 2A. Values are OR (95CI) sunbed use compared with 2007 pre-campaign measurement adjusted for gender, age, education, region and skin type.

Figure 2B. Values are OR (95CI) sunbed use compared with 2007 pre-campaign measurement adjusted for gender, age, education, region and skin type.

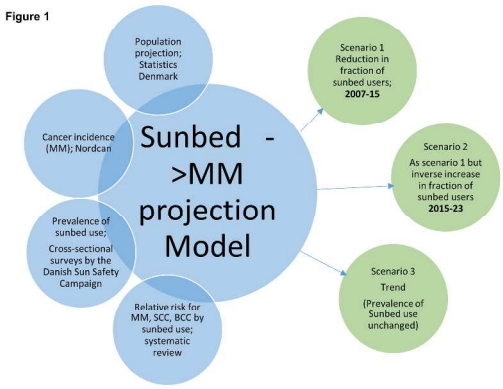
Figure 3a

The expected number of MM cases, when sunbed use is unchanged, there is a reversible or irreversible campaign effect. Assumed estimated annual percentage change 2007-2022 (4% increase) and 2022-2040 (0% constant). LAT time of 2 years and LAG time of 5 years.

Figure 3b
The expected number of SCC cases, when sunbed use is unchanged, there is a reversible or irreversible campaign effect. Assumed estimated annual percentage change 2007-2022 (4% increase) and 2022-2040 (0% constant). LAT time of 2 years and LAG time of 8 years.

Figure 3c
The expected number of BCC cases, when sunbed use is unchanged, there is a reversible or irreversible campaign effect. Assumed estimated annual percentage change 2007-2022 (4% increase) and 2022-2040 (0% constant). LAT time of 2 years and LAG time of 8 years.

Figure 1



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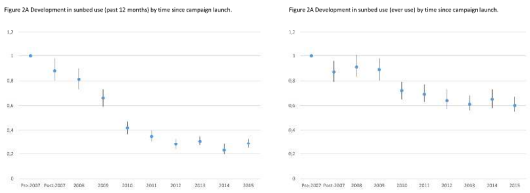

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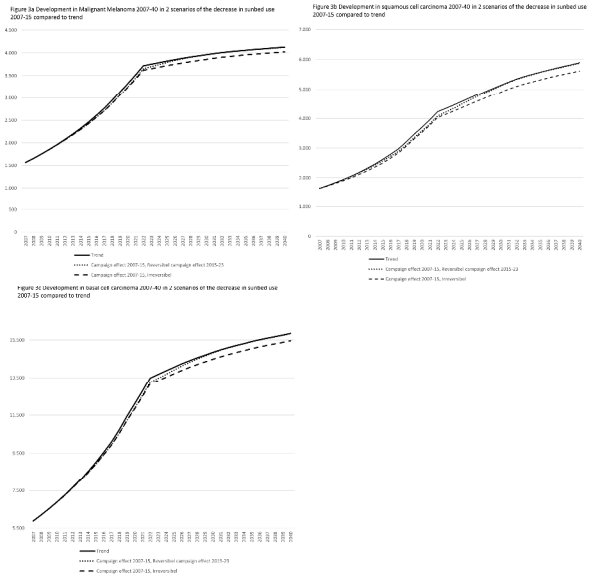

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Supplemental table S1a Percentage of sunbed use (past 12 months) by demographic characteristics and year of measurement in cross-sectional surveys in Denmark 2007-2015 of 37.766 Danes**.**

Characteristic **(%)** Total (n)	Total (n)	% or mean	March 2007 (%)	August 2007	August 2008	August 2009	August 2010	August 2011	August 2012	August 2013	August 2014	August 2015
Total (n)	37766	**18**	4303	4451	4277	4186	4156	4130	2195	4022	2047	3999
Gender	*p<0.001*		*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*
Male	18437	**13**	18	14	16	16	12	10	10	11	8	8
Female	19300	**22**	32	31	34	28	19	16	12	12	11	13
Agegroup	*p<0.001*		*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*0.008*	*p<0.001*	*p<0.001*	*p<0.001*
15-19	3417	**27**	50	48	44	33	18	12	9	13	14	15
20-29	6017	**25**	47	45	38	32	22	17	16	15	13	12
30-39	7409	**19**	31	31	28	22	14	15	11	10	8	10
40-49	8442	**18**	26	22	23	23	17	15	11	13	11	12
50-59	7547	**12**	18	16	15	14	12	10	8	9	5	7
60-64	3933	**8**	15	10	8	11	5	6	8	8	3	5
Skintype	*p<0.001*		*p<0.001*	*0.003*	*0.015*	*0.154*	*0.002*	*p<0.001*	*0.123*	*0.006*	*0.068*	*0.025*
I	4550	**13**	23	19	20	18	9	6	8	8	6	10
II	19316	**18**	24	25	26	22	16	13	12	12	9	10
III	12203	**19**	30	23	27	22	16	15	11	13	11	13
IV	735	**23**	30	33	25	27	13	21	19	17	14	16
Region	*p<0.001*		*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*0.007*	*0.008*	*p<0.001*	*p<0.001*	*0.176*	*0.487*
Capital	13065	**15**	20	21	23	18	12	10	6	8	7	10
Zealand	4680	**16**	24	26	18	21	15	13	14	12	10	10
Northern Jutland	7028	**21**	35	29	29	25	17	16	14	16	10	13
Central Jutland	8086	**19**	30	29	28	26	16	15	12	12	10	10
Southern Denmark	3749	**18**	30	20	29	22	17	13	13	13	11	12
Education	*p<0.001*		*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*0.009*	*0.024*	*0.359*	*0.067*	*0.017*
< 10 years	9372	**17**	32	29	24	20	12	12	10	11	6	9
10-12 years	14881	**20**	30	28	29	26	18	15	10	13	11	12
>12 years	12909	**15**	21	20	20	16	13	11	14	11	9	10
Sunbathe	*p<0.001*		*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*
Yes	24350	**24**	33	32	34	29	20	18	15	15	12	15
No	13416	**7**	7	11	9	8	6	5	5	6	3	3
Have children	*p<0.001*		0.198	0.028	0.233	0.596	0.240	0.087	0.414	0.320	0.771	0.155
Yes	12527	**18**	27	25	24	21	14	14	12	11	9	12
No	25239	**17**	25	23	26	22	16	12	11	12	9	10

p-values are for χ^2-test between observed and expected (average) factor levels.

Supplemental table S1b Percentage of sunbed use (ever use) by demographic characteristics and year of measurement in cross-sectional surveys in Denmark 2007-2015 of 37.766 Danes**.**

Characteristic **(%)** Total (n)	Total (n)	% or mean	March 2007 (%)	August 2007	August 2008	August 2009	August 2010	August 2011	August 2012	August 2013	August 2014	August 2015
Total (n)	37766	**52**	4303	4451	4277	4186	4156	4130	2195	4022	2047	3999
Gender	*p<0.001*		*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*
Male	18437	**39**	40	36	40	43	39	40	38	38	38	35
Female	19300	**64**	68	66	72	70	61	62	60	57	59	58
Agegroup	*p<0.001*		*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*0.008*	*p<0.001*	*p<0.001*	*p<0.001*
15-19	3417	**40**	57	57	61	51	34	28	22	23	27	22
20-29	6017	**60**	79	78	70	67	59	59	56	53	51	44
30-39	7409	**68**	77	74	71	69	66	64	65	60	62	62
40-49	8442	**59**	61	57	58	59	59	58	56	57	61	60
50-59	7547	**41**	44	40	38	45	42	44	42	40	41	40
60-64	3933	**32**	37	31	35	36	29	33	26	33	26	33
Skintype	*p<0.001*		*p<0.001*	*0.003*	*0.015*	*0.154*	*0.002*	*p<0.001*	*0.123*	*0.006*	*0.068*	*0.025*
I	4550	**52**	60	54	55	57	51	50	53	48	51	48
II	19316	**54**	56	56	58	60	55	54	50	51	52	47
III	12203	**49**	55	49	53	52	49	48	47	44	41	47
IV	735	**49**	51	53	51	53	40	47	44	46	51	46
Region	*p<0.001*		*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*0.007*	*0.008*	*p<0.001*	*p<0.001*	*0.176*	*0.487*
Capital	13065	**51**	54	52	55	55	51	51	48	47	46	47
Zealand	4680	**49**	51	54	50	54	48	48	48	46	44	43
Northern Jutland	7028	**55**	59	56	61	62	50	51	52	52	54	51
Central Jutland	8086	**53**	60	55	56	60	55	52	51	48	48	45
Southern Denmark	3749	**51**	56	50	58	51	53	50	48	48	51	47
Education	*p<0.001*		*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*0.009*	*0.024*	*0.359*	*0.067*	*0.017*
< 10 years	9372	**44**	48	44	49	49	42	41	34	40	31	41
10-12 years	14881	**56**	61	57	60	62	57	56	52	48	44	47
>12 years	12909	**54**	55	53	56	57	52	54	59	53	52	50
Sunbathe	*p<0.001*		*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*
Yes	24350	**61**	65	63	67	66	61	61	58	55	55	56
No	13416	**35**	31	36	35	37	35	36	35	34	36	31
Have children	*p<0.001*		0.198	0.028	0.233	0.596	0.240	0.087	0.414	0.320	0.771	0.155
Yes	12527	**60**	65	63	62	63	62	59	62	51	49	55
No	25239	**48**	51	47	52	53	47	47	44	46	48	43

p-values are for χ^2-test between observed and expected (average) factor levels.

Supplemental table S2 Logistic regression analysis of sunbed use (past 12 months) in Denmark 2007-2015 by demographic factors and annual percentage decrease in sunbed use overall and by factor levels.

Characteristic **(%)** Total (n)	Total (n)	% or mean	Crude OR (95 C.I.)	[a)]Adjusted OR (95 C.I.)	[b)]Adjusted OR (95 C.I.)	Sunbed use annual change	Sunbed use annual change (adjusted)
Total (n)	37562	18	34616	34616	34616	0.97 (0.97-0.97)	**0.96 (0.96-0.97)**
Gender			*p<0.001*	*p<0.001*	*p<0.001*		
Male	18325	13	1 (ref)	1 (ref)	1 (ref)	0.99 (0.98-0.99)	
Female	19237	22	1.96 (1.85-2.08)	2.12 (2.00-2.25)	1.74 (1.63-1.85)	0.96 (0.95-0.96)	
Agegroup			*p<0.001*	*p<0.001*	*p<0.001*		
15-19	3383	27	4.00 (3.48-4.60)	4.15 (3.59-4.80)	3.41 (2.94-3.96)	0.92 (0.91-0.93)	
20-29	5970	25	3.52 (3.09-4.00)	4.21 (3.67-4.83)	4.21 (3.66-4.85)	0.94 (0.93-0.95)	
30-39	7369	19	2.55 (2.24-2.90)	3.21 (2.79-3.70)	3.19 (2.77-3.69)	0.96 (0.96-0.97)	
40-49	8419	18	2.39 (2.10-2.71)	2.84 (2.47-3.25)	2.67 (2.32-3.07)	0.98 (0.98-0.98)	
50-59	7529	12	1.48 (1.30-1.70)	1.57 (1.37-1.87)	1.45 (1.26-1.66)	0.98 (0.98-0.99)	
60-64	3922	8	1 (ref)	1 (ref)	1 (ref)	0.99 (0.99-0.99)	
Skintype			*p<0.001*	*p<0.001*	*p<0.001*		
I	4534	13	0.45 (0.37-0.54)	0.32 (0.26-0.39)	0.43 (0.35-0.53)	0.98 (0.97-0.98)	
II	19252	18	0.67 (0.56-0.80)	0.59 (0.49-0.71)	0.64 (0.53-0.78)	0.97 (0.97-0.97)	
III	12141	19	0.74 (0.62-0.89)	0.74 (0.62-0.90)	0.80 (0.66-0.98)	0.97 (0.97-0.97)	
IV	733	23	1 (ref)	1 (ref)	1 (ref)	0.96 (0.95-0.98)	
Region			*p<0.001*	*p<0.001*	*p<0.001*		
Capital	12998	15	1 (ref)	1 (ref)	1 (ref)	0.97 (0.97-0.98)	
Zealand	4652	16	1.10 (1.01-1.21)	1.15 (1.04-1.27)	1.32 (1.20-1.46)	0.98 (0.97-0.98)	
Northern Jutland	3730	21	1.54 (1.40-1.69)	1.60 (1.45-1.76)	1.73 (1.57-1.91)	0.96 (0.95-0.97)	
Central Jutland	8042	19	1.36 (1.26-1.47)	1.40 (1.30-1.51)	1.51 (1.40-1.64)	0.96 (0.96-0.97)	
Southern Denmark	6985	18	1.25 (1.16-1.36)	1.30 (1.20-1.41)	1.44 (1.32-1.57)	0.97 (0.97-0.98)	
Education			*p<0.001*	*p<0.001*	*p<0.001*		
< 10 years	9313	17	1.13 (1.05-1.22)	1.25 (1.15-1.36)	1.37 (1.26-1.49)	0.96 (0.95-0.96)	
10-12 years	7130	20	1.40 (1.23-1.40)	1.25 (1.17-1.34)	1.37 (1.28-1.47)	0.96 (0.96-0.97)	
>12 years	7682	18	1 (ref)	1 (ref)	1 (ref)	0.98 (0.97-0.98)	
Sunbathe			*p<0.001*	N.A	*p<0.001*		
Yes	24240	24	4.16 (3.85-4.49)		3.47 (3.20-3.77)	0.96 (0.96-0.96)	
No	13322	7	1 (ref)		1 (ref)	0.99 (0.99-0.99)	
Have children<18 in household			N.S.	*p<0.001*	*p<0.001*		
Yes	12461	18	1.01 (0.96-1.07)	0.87 (0.81-0.93)	0.94 (0.89-0.99)	0.97 (0.97-0.98)	
No	25101	17	1 (ref)	1 (ref)	1 (ref)	0.97 (0.97-0.97)	
Temperature (Degree celsious)			*p<0.001*	N.A	*p<0.001*		
			1.29 (1.26-1.33)		1.51 (1.44-1.59)		
Sunhours (/100/summer)			*p<0.001*	N.A	*p=0.023*		
			1.14 (1.09-1.19)		1.25 (1.05-1.49)		
Days with rain /month			*p<0.001*	N.A	*p<0.001*		
			0.96 (0.95-0.97)		1.07 (1.05-1.09)		

Odds ratios and confidence intervals (CIs). a) Model adjusted for gender, age, education, skin type, have children and region. b) Model additionally adjusted for sunbathing and weather indicators

STROBE Statement—checklist of items that should be included in reports of observational studies
Items are present at PageX and LineY: PXLY

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract: P3L4
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found P3
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported P4L3-P4L25
Objectives	3	State specific objectives, including any prespecified hypotheses P4L47-P5L2
Methods		
Study design	4	Present key elements of study design early in the paper P5L6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection P5L12-23
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants P5L12-23
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable P5L12-P5L36
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group P5L38-P6L8
Bias	9	Describe any efforts to address potential sources of bias P5L12-36
Study size	10	Explain how the study size was arrived at P5L12-23 and table1
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why P5L38-P6L8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding P5L38-P6L8
		(*b*) Describe any methods used to examine subgroups and interactions P5L12-P6L8
		(*c*) Explain how missing data were addressed Not relevant due to sampling methodology
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy P5L7-P6L8
		(*e*) Describe any sensitivity analyses P7L25-27

Continued on next page

Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed P7L31-43, Table 1
		(b) Give reasons for non-participation at each stage P7L31-43, Table 1
		(c) Consider use of a flow diagram Not relevant
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders P7L31-43, Table 1-2
		(b) Indicate number of participants with missing data for each variable of interest Table 1
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures Table 2
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included P8L12-39, Table 3, Figure 3
		(*b*) Report category boundaries when continuous variables were categorized Table 3
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period P8L12-39, Table 2-3, Figure 3
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses P8L34-39, Tabel 3
Discussion		
Key results	18	Summarise key results with reference to study objectives P9L1-6
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias P9L8-28
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence P9L30-37
Generalisability	21	Discuss the generalisability (external validity) of the study results P9L39-P10L12
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based P10L27

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Repeated Cross-Sectional Surveys of Sunbed Use 2007-15 and Skin Cancer Projections of Campaign Results 2007-40 in the Danish Population

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Repeated Cross-Sectional Surveys of Sunbed Use 2007-15 and Skin Cancer Projections of Campaign Results 2007-40 in the Danish Population

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Running title: Development in sunbed use 2007-15 in Denmark

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Statement of independence of researchers from funders:

The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Keywords: Skin Cancer, Prevention, Malignant Melanoma Projections, Campaign, Ultraviolet Radiation, Questionnaire

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Transparency declaration:

Brian Køster affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

Abstract

Objective: To evaluate the effect of the Danish Sun Safety Campaign 2007-15 on the prevalence of sunbed use and to model future effects on the skin cancer incidences 2007-40.

Design: The study is a repeated, cross-sectional design.

Setting: Exposure to ultraviolet radiation is the main risk factor for skin cancer. Denmark has the highest prevalence of sunbed use reported and one of the highest incidence of skin cancer worldwide.

Participants: During 2007-15, survey data was collected for 37 766 Danes, representative for the Danish population in regards to age, gender and region.

Interventions: In 2007, an ongoing long-term anti-sunbed campaign was launched in Denmark.

Primary and secondary outcome measures: Sunbed use was evaluated by annual cross-sectional surveys. Skin cancer incidence was modelled in the Prevent program, using population projections, historic cancer incidence, sunbed use exposure and relative risk of sunbed use on melanoma.

Results: The prevalence of recent sunbed use in Denmark was reduced from 32% and 18% to 13% and 8 % for women and men, respectively. The campaigns results during 2007-15 is estimated to reduce the number of skin cancer cases with more than 5 000 (746 MM, 1562 SCC, 2673 BCC) totally during 2007-40. Keeping the 2015-level of sunbed use constant by a continued campaign pressure or introduction of structural interventions would potentially prevent more than 750 skin cancer cases annually in 2040 and 16 000 skin cancer cases in total during 2007-40.

Conclusion: We have shown the value of prevention and the value of long term planning in prevention campaigning. Sunbed use was reduced significantly during 2007-15 and further reductions are possible by structural interventions. Consequently, significant fewer skin cancer cases are anticipated 2007-40. The Danish parliament has population support to enforce structural interventions to avoid a large burden of this disease.

Strength and Limitations

- Long term funding and planning secured the continuity in this study, comparability of data over time and the achievements of results
- High awareness created by the campaign could cause e.g. political correctness bias or selection bias
- Projection models can be influenced by changes in improved diagnostics, equipment, change in strength of UV spectrum or output in sunbeds or other changes in population UV-exposure

Introduction

Exposure to ultraviolet radiation (UVR) is the main modifiable risk factor for keratinocyte skin cancers (SCC and BCC) and malignant melanoma (MM) skin cancer (1, 2). Intermittent exposure to UVR from the sun and sunbeds, and sunburn history, are important factors in the etiology of skin cancer (3, 4). In Denmark, the MM incidence (world standardized rate per 100 000) for men and women increased from 1.4 and 1.9 in 1949–1953 to 21.4 and 26.7 in 2010–2014, respectively (5). The development is or was similar in most Caucasian populations, including in Northern European countries (6). Similarly, keratinocyte skin cancer incidence increased manifold in the same period. Presumably because of improved primary and secondary prevention, improved diagnostics (7, 8) and change in sun exposure patterns including increased number of Danes travelling abroad since the 1960's and the introduction and spread of sunbed facilities in the 1980's. Half of the Danish population travel to sunny destinations each year (9, 10), approximately 60 % have ever used a sunbed (11) and 40 % were sunburnt annually (9, 12).

In 2009, the International Agency for Research on Cancer classified ultraviolet- emitting tanning devices as 'carcinogenic to humans' with respect to MM (13). (4, 14-17). The increased risk of MM was especially high among sunbed users younger than 30-35 years, and more than 75 % of cases diagnosed in this young age was caused by sunbed use. Additionally, sunbed use was shown to increase the risk of MM without the presence of sunburn (15, 17). Boniol et al. summarized the risk of MM from sunbed use in a systematic review to be 1.2 for ever-use of sunbed and 1.59 for sunbed use initiated before the age of 35. Furthermore, a dose response relationship was established between frequency of sunbed use and MM with an increased risk of 2 % for each extra annual session (18). The increased risk of developing basal cell carcinoma and squamous cell carcinoma from sunbed use was summarized by Wehner et al. (19) to 1.29 and 1.67, respectively. Sunbed use is highly prevalent in Denmark, especially in younger age groups and more than half of those recalling their age of initiation of sunbed use reported to have started before age 18 (20, 21). Sunbed use was estimated to be responsible for 13 % and 8 % of MM cases in Denmark in women and men (18).

Campaign content

In May 2007, an anti-sunbed campaign was launched, with young people aged 15–25 as the primary target. The campaign was based mainly on social media and also magazines and radio, the traditional youth targeted media. The campaign was very successful, with viral dissemination of video clips, music videos and other materials that made links between sunbed use, negative cosmetic effects and skin damage and educational programs including a pocket movie competition in 7th graders making them ambassadors for anti-sunbed campaigning.

The public activities included lobbying at national and local government levels and a public campaign program. The lobbying focused on legal prohibition of sunbed use for children under 18 years of age and the removal of sunbeds from, e.g. local sport facilities and pools under local government administration. In summer 2009, politicians spoke out in favor of legal restriction of sunbed use by children under 18 years of age. During spring and summer of 2009, some local governments started removing sunbeds from public facilities, and in 2017, the majority of local governments have removed sunbeds from their buildings. Only six out of 98 local governments still have sunbeds in their buildings and in two of those age restrictions (<18 y) have been implemented. However, the majority of sunbed operators in Denmark are commercial and not influenced by these restrictions. The campaign generated press coverage and political debate, which raised public awareness of the health risks associated with sunbed use, included more than 2700 press clips on sunbed topics during the period of the study.

We studied the development in sunbed use in Denmark after the start of a 10-year national sun protection campaign in March 2007. The aims of this study is 1) to show the possible effects of the Danish Sun Safety

Campaign on prevalence of sunbed use and 2) to estimate potential reductions in future skin cancer incidence by the campaign.

Materials and Methods

Overview

We estimated the effect of the Danish Sun Safety Campaign during 2007-15 in terms of annual reduction in the fraction of ever users of sunbed. We modelled projections of future cancer incidence, introducing the effects of the campaign and compared with status quo using realistic estimates of relative risks in the intervention scenarios to obtain an indication of the long-term impact of the campaign interventions on cancer incidence.

Questionnaire and confounding

During 2007-2015, a question on frequency of sunbed use was included in the annual population-based questionnaires on exposure to UV radiation and behavior and attitude towards UV exposure. In total, 37 766 Danes answered the 75-item questionnaire. Data was collected by computer assisted web interview (CAWI) by Epinion (2007 and 2014-15) and Userneeds (2008-13). Data was collected as representative for the Danish population by gender, age, region and education. The education variable included 7-10 options during the period and it was condensed into the three categories as shown in table 1. For the initial measurements in 2007, there was no higher age limit and persons 65 and older were categorized as missing to be able to compare to following measurements. Since 2009, a limited number of internet panels were available, which were able to provide the respondent structure requested. To avoid measuring only effect in the panel and not in the population, it was a requirement that maximum 25 % of the participants were allowed to participate in the survey the following year, because answering a questionnaire could influence the behavior. Detailed data sampling strategies are available in annual survey reports on skrunedforsolen.dk (22). Exposure to artificial UVR was determined by the question: ('How often did you use a sunbed within the past 12 months?': 'More than once a week, Once a week, More than once a month, Once a month, Fewer than four times a year, Not within the past twelve months, Never'); The questionnaire also elicited information on behavior with respect to exposure to natural UVR; these results will be reported separately. The question about sunbathing was included in the analysis to distinguish between intentional and non-intentional tanning (1). As data collection and panel composition evolved as well differences exist between years. Age was included in all analysis as five or 10-year age groups. Teenagers were kept as '15-19 years' as their behavior was shown to differ from that of the adult population (23, 24). Skin types were determined from self-assessed tan and sunburn reactions, according to Fitzpatrick skin type I (never tan, always burn) to skin type IV-VI (always tan, never burn)(25).

The accumulated sun hours and average temperature of June and July was included in the regression analysis as Danes could be more prone to use sunbed when the weather conditions makes outdoor sunbathing impossible and significant variation in weather measures occurred during the period analyzed.

Patient involvement

The Danish Sun Safety Campaign has continuously used information from for example interviews and focus groups with patients, at-risk groups and lay people in an iterative setup to improve campaign elements as well as annual evaluations of the campaign. Recruitment is described above and dissemination of results will be by scientific publication, national press as well as patient organization newsletters from the Danish Cancer Society.

Analysis

Answers to sunbed use were grouped into 'recent users' and 'non-recent users' and 'ever users' and 'never users', respectively. Recent use was defined as use within the past 12 months. Similarly, ever-use of sunbed was defined as belonging to all categories except the 'never' category. Recent use was modelled to describe immediate changes in sunbed use according to aim 1 and ever-use was modelled for use in the cancer projections for aim 2. The homogeneity of respectively recent and ever sunbed use over time of survey and demographic variables was examined. The outcome 'sunbed use, yes / no' was analysed using logistic regression. The factors included in the model, as categorical variables, were gender, age, education, skin type, having children below age 18 in household and region. Factors with a statistically significant different distribution were included as possible explanations. Adjusted odds ratios (ORs) and 95% confidence intervals (CIs) were calculated. The *p*-values from the logistic regression analysis refer to either tests for variation between the factor levels by time (year) or trend as stated for the relevant analysis. For all tests, P values < 0.05 were considered statistically significant. The procedure logistic in SAS version 9.3 (SAS Institute, Cary, NC, USA) was used for the analyses.

The prevent model

Projection of future incidence was estimated using Prevent (26, 27). This program was adapted for the Eurocadet project to model future cancer incidence by implementation of lifestyle preventive strategies. Prevent calculated the percentages of potentially prevented cases under the scenario of interest as compared to the status quo scenario. If the scenario of interest is no exposure or exposure with minimum impact on risk, this percentage is interpretable as the population attributable fraction (PAF) of sunbed use experience, respectively, on skin cancer (MM, SCC, BCC) incidence by the year 2040: they represent the numbers of cases that would be prevented had the population not used sunbed and therefore the fraction of MM, SCC and BCC cases attributable to these risk factors. Three types of data are needed to run the model; 1) demographic data (current and projected population sizes by age and sex), 2) risk factor-related data (prevalence, changes in prevalence as a result of interventions and risk estimates) and 3) disease incidence data (cancer rates and estimated annual percentage change to account for trends in disease incidence that are not associated with modelled risk factor data). The projected numbers of new cancer cases were computed based on the demographic data and under different scenarios of changes in the prevalence of risk factors. Results are projected rates and numbers with and without modelled interventions by risk factor prevalence. The model is summarized in figure 1.

Exposure: Sunbed use

The prevalence of sunbed use was derived from sun behavior questionnaires of The Danish Sun Safety Campaign as described above. The campaign was the only initiative in Denmark collecting data on UVR exposure continuously since 2007 (9, 12, 28-31). In the Prevent model, sunbed use was included as ever/never use. The change in prevalence of sunburn applied in the population projections was from logistic regression analysis.

Incidence data

National incidence rates for melanoma and keratinocyte skin cancer (ICD-10 code: C43 and C44) by sex and 5-year age groups were retrieved from NORDCAN (5). The estimated annual percentage change (EAPC) for men and women for the past 25 years, respectively, was 6.4 % and 10.9 % increase for SCC, 5.4% and 7.4 % for BCC and 4.4 % and 4.5 % for melanoma (5). We chose to use a uniform conservative 4% increase in all skin cancer rates for men and women for the modelling. The EAPC was applied for the first 15 years after

which it remained constant at this level. For sensitivity analysis, we applied an EAPC respectively of 0 and 30 years. The registration of keratinocyte skin cancer C44 is probably more complete in Denmark than in most other countries. Since 2004 the cancer registration has been made by a linkage between the national hospital register, the pathology register, and the cause of death register. For both melanoma skin cancer, C43, and C44, keratinocyte skin cancer, divided into BCC and other keratinocyte skin cancers, mainly SCC, registrations are also included based on a registration in the pathology register alone from 2004 and on.

Population projections

From Statistics Denmark we obtained the size of the population on January 1st, of the corresponding period of the latest available incidence data by 1-year age category and sex as well as forecasted population sizes for each year up to 2040 by 5-year age categories and sex, using the medium national growth estimates.

Effect of sunbed use on the incidence of melanoma skin cancer.

Relative risks for sunbed use on the risk of MM and keratinocyte cancers were derived from the largest meta-analysis', on the subject, established by respectively Boniol et al. and Wehner et al. MM: RR= 1.2 for >35-year-olds and RR = 1.59 for < 35-year-olds and RR for SCC and BCC of 1.67 and 1.29 respectively. (18, 32). These findings were used as the relative risks and risk functions in our modelling (fig. 1). The relative risks and risk functions were assumed equal for all age groups within age bands and included in the study, and across time. The effect of a risk factor exposure on cancer incidence has a latency time. Prevent accommodates this through two time lags: 1) the time that the risk remains unchanged after a decline in risk factor exposure (LAT) and 2) the period during which the changes in risk factor exposure gradually affect the risk of cancer, eventually reaching risk levels of the non-exposed (LAG)(26). Thus, assuming that sunbed users who quit sunbed use following the campaign after a total of (LAT + LAG) years are no longer at increased risk of skin cancer. For this study, we used for sunbed use a LAT of 2 years and a LAG of 5 years for MM and respectively 2 and 8 years for keratinocyte cancers. LAG was modelled as a linearly declining risk. LAT and LAG periods for sunbed use on risk of skin cancers has not been estimated precisely. Pil et al. used an induction period of 20 years, however we chose shorter time periods for MM from the knowledge of intermittent exposure pathway (1) and the experiences from Iceland (33) and sunbed use in young people (14). In Iceland both a drastic increase and following decrease in melanoma incidence was observed within a 10-year period preceded by complimentary delayed increase and decrease, respectively, in the number of available sunbed salons. The MM incidence change was primarily driven by people below 50 and trunk site melanomas, which are characteristic for intermittent/sunbed exposure.

We have modelled the development in future skin cancer Incidence in Denmark in three scenarios. We have used the reductions in sunbed use during 2007-15 to model MM Incidence in 2007-40.

- Scenario 1) We assume the campaign is discontinued after 2015 and that the rate of sunbed use remains constant afterwards (Irreversible campaign effect)
- Scenario 2) Similar to scenario 1 except, we have modelled a conservative 'spring effect' where the prevalence of sunbed use returns to pre campaign level in the inverse rate as it was reduced 2015-2023 (reversible campaign effect)
- Scenario 3) The expected trend if prevalence of sunbed use is unchanged (trend/no campaign effect)

We have also applied sensitivity analyses to the conservative scenario 2. We have used the applied EAPC for 0, respectively 30 years instead of 15. We have applied a combined LAT+LAG time of either zero or twice the time, of the main scenario.

Results

Table 1 shows the distribution of demographic characteristics from annual data collections during 2007-15. Answers were collected from more than 4000 persons/survey, except for 2012 and 2014 were 2000 persons/survey was settled for due to challenges with data collection of certain groups, especially young (15-19 y) men. For all included variables, we found significant variation over years. Only 2007 data collections differed for gender, after which sampling methods were optimized. In 2007 there was no higher limit for age, however in this analysis persons older than 65 were excluded, which lead to differences in the distribution of age compared to 2008-15. There was more people characterized with paler skin types in 2013-15. Region and education was not used in the sampling all years, which mean that e.g. august 2007 data are overrepresented by persons from region capital. Education was differently distributed in panels and in panel characterizations of education between years. Persons who reported sunbathing declined during the campaign period. Persons having children 18 or younger staying at home also varied. Weather varied randomly for the variables mean temperature, mean monthly number of sunhours and mean monthly days with rain.

Supplemental table S1a and b shows the detailed distribution of sunbed use, recent and ever-use respectively. In all the annual surveys, there are differences for all included variables except having children. In general, more women used sunbed and sunbed use decreased by age. More persons with dark skin types used sunbed and sunbed use was more prevalent in Northern Jutland and the less prevalent in region Capital. Fewer persons with more than 12 years of education used sunbed, while more persons who sunbathed also use sunbeds.

Figure 2a and b shows the adjusted odds-ratio (OR) and 95 C.I: of the development in sunbed use (recent and ever-use respectively) adjusted for gender, age, education, region and skin type, with the March 2007 measurement as reference point. The decrease in sunbed use was largest in the beginning of the campaign period and until about 2011/12, where the decrease leveled. In 2015, the OR for sunbed use was approximately 0.3 compared to the pre-campaign measurement in March 2007.

Table 2 (ever-use) and supplemental table S2 (recent use) shows the logistic regression analysis of the sunbed use in Denmark by demographic factors in the left part of the table and in the right part is shown the annual percentage change in sunbed use per year. Age and skin type are the variables most influential on sunbed use. We have shown the crude OR (95 C.I.) and a model adjusted for gender, age, skin type, region, education and having children below 18 in household. Due to the large differences in education in our analysis of the development of sunbed use, we also tried to exclude education, but that did not change the estimates significantly. In addition, we examined the influence by weather parameters in a model additionally adjusted for temperature, number of sunhours and days with rain. We found that increasing temperature, number of sun hours and number of days with rain was associated with increased sunbed use. In the right side of tables 2 and S2 is shown the crude reduction by annual measurement. Females reduced their recent sunbed use more than men and young persons more than older persons, especially the 15-29-year-olds. There was no significant differences in reduction by skin type, region, education, sunbathing or among people with or without children. Overall, the adjusted analysis for ever-use of sunbed showed an annual reduction of more than 3 % per year in the campaign period. For recent sunbed use the annual reduction was 4 % per year.

The prevalence of sunbed use influence on future skin cancer incidence

In figure 3a-c, we have modelled the development in the number of future MM, SCC and BCC Incidence cases according to scenarios 1-3 in Denmark. The effect of the campaign results in a reduction of 103 MM,

271 SCC and 387 BCC skin cancer cases pr. year in 2040 and in total 2443 MM, 5383 SCC and 8437 BCC cases during 2007-40, while if the effect of the campaign is reversed to pre-campaign level there will be no change in annual number of skin cancer cases in 2040 but a total reduction of 746 MM, 1562 SCC and 2673 BCC cases during 2007-40. The results of the skin cancer reductions projections including relative reductions are summarized in table 3. The table also includes the projections for the sensitivity analysis for scenario 2 where EAPC and LAT+LAG were examined. There was a minimum and a maximum of 423 and 869 fewer MM cases, respectively, during 2007-40. Minimum and maximum of all skin cancer types were 6208 and 11 972 fewer cases totally during 2007-40. The relative decrease is larger for irreversible campaign effects compared to reversible. The sensitivity analysis variations of scenario 2 were robust to changes in cancer incidence and time to effect.

Discussion

We have shown that the Danish Sun Safety Campaign reduced the recent sunbed use during 2007-15, from 32 % and 18 % to 13 % and 8 % for women and men, respectively. The OR for recent sunbed use in 2015 compared to the pre-campaign level was 0.3. We have modelled these results in respect to future skin cancer incidences and expect more than 750 fewer cancer cases annually in 2040 and more than 16.000 fewer cases totally until 2040, as the campaign is still ongoing. Had the campaign been terminated after 2015, it may not influence the annual number of skin cancers in 2040, however during 2007-40 still more than 5 000 skin cancer (MM, SCC and BCC) cases would have been avoided.

Strengths and limitations

The unique strengths of this study is the possibility of long time planning, securing the continuity in the campaign including comparable wordings in the questionnaires and personnel to secure comparable evaluations over the entire period as well as long term funding has made the high continuous campaign pressure possible.

There is a risk that the high awareness created by the campaign could have caused political correctness bias meaning that e.g. persons would have falsely stated no to sunbed use in questionnaires. Similarly selection bias may have occurred, e.g. if sunbed users were less prone to participate in surveys of this subject.

A prognosis of the cancer incidence in absolute numbers is difficult to provide as, there are unknown indicators, which we were not able to include in the model like improved diagnostics, equipment, change in strength of UV spectrum or output in sunbeds (7, 34) or other changes in UV-exposure. As we have used the difference between two cancer incidence rates this had minor influence on the results. The prevent model primarily gives useful measures of the influence of change in use of sunbeds. The model accuracy is as good as the quality of the data input and dependent on the assumptions applied for the scenarios. Exact LAT and LAG times are not determined; however, varying LAT+LAG times were included in the sensitivity analysis and their relative estimates were within a reasonable range. Model based results should be interpreted with caution and mentioning of limitations.

The number of skin cancer cases in the years passed is different from the actual incidence development because it is influenced by factors not included. About year 2002-04 the dermatoscope was introduced among dermatologists in Denmark, which probably increased the rate of detection (7) for a while. In the following period a plateau is seen from around 2011 (5). The decreasing incidence rate is likely to be a consequence of the earlier detection/treatment, an effect also seen in various screening programs. While the increasing skin cancer incidences raised the media awareness of the disease in the ‘90s, in 2007, the

multi component Intervention of the Danish Sun Safety Campaign increased this awareness manifold. The increased awareness may have lead to an increase in mole check by the general physician, which could have increased the number of diagnoses; however we were not able to measure this.

Reduction in sunbed use

Denmark had one of the highest reported frequencies of sunbed use in the world before the Danish Sun Safety Campaign was launched. The largest reductions in sunbed use occurred among the youngest age groups and among females, which had the highest prevalence of sunbed use and were the main targets of the campaign. Even though large reductions in sunbed use occurred, the prevalence of sunbed use in Denmark is now just comparable to other European countries, e.g. 14 % within the past year in Germany in 2012 (35). Concerning campaign efficiency, there have been anti-sunbed campaigns in e.g. UK, Canada, US and Australia, which have also shown reductions, however our baseline use are not similar and comparable. The past years of the reductions in sunbed use has leveled of perhaps as a consequence of a changed focus of the Danish Sun Safety Campaign towards sunny holidays or perhaps the remaining sunbed users are less perceptible of risk communication.

Consequences and recommendations

Pil et al. (36) have previously modelled the effect of various scenarios thought to prevent skin cancer. Our results are based on an actual intervention with measurable results of the exposure; therefore, our modelling results of the future cancer incidence are a realistic prognosis of the incidence change. Likewise, we have shown the importance of a continued campaign pressure to achieve these goals (difference between model 1 and 2).

The WHO suggests countries bans sunbeds or alternatively restrict (staff supervision, age limit, high-risk individuals), manage (license, radiation output and time limits, staff training, tax) and inform (health risks, display warning, ban marketing) to protect their populations (37). In 2017, the majority of countries in Western Europe and the majority of American states have introduced age limits for sunbed use to protect children, and states with age limits succeeded in reducing the prevalence of sunbed use (38). Furthermore, Australia and Brazil has completely banned sunbed use to protect their populations against the detrimental effects of sunbed use on human health and to reduce government spending related to skin cancer diagnostics and treatment (39). Belgium is to our knowledge the first European country to recommend a ban against sunbed use (40), while Denmark is now one of few remaining western European countries without an age limit to protect children (41).

Emphasizing the health potential of the achieved results, we hope to motivate government administration to implement structural interventions to reduce the sunbed use in Denmark as well as in countries with similar problems as in Denmark. We specifically address the need for a revision of the Danish sunbed legislation adopted in 2014.

Conclusion

The Danish Sun Safety Campaign has significantly reduced the sunbed use in Denmark since 2007. Several legislative restrictive measures exists which would be beneficial to introduce to reduce the sunbed use further at the current stage and to avoid that the sunbed use increases again if campaigning is not available. Because of the campaign, we expect fewer skin cancer cases in Denmark in the future. Danish

politicians have the opportunity, supported by the population, to reduce the skin cancer incidences further and thereby to reduce the future costs of skin cancer.

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Conflicts of interest

The authors have declared that no competing interests exist. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Data sharing: Full dataset available from the corresponding author.

Authorship Contribution Statement

BK, MM, TA, GE and PD have contributed to conceptualization and design of the study, analysis and interpretation of data, critical revision of the manuscript and final approval of the manuscript. BK drafted the manuscript.

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Table 1. Distribution of demographic characteristics in cross-sectional surveys on UV-exposure 2007-2015 of 37 766 Danes.

Characteristic **(%)**	Total (n)	% or mean	March 2007 (%)	August 2007	August 2008	August 2009	August 2010	August 2011	August 2012	August 2013	August 2014	August 2015
Total (n)	37766	**100**	4303	4451	4277	4186	4156	4130	2195	4022	2047	3999
Gender	*p<0.001*											
Male	18437	**49**	44	44	50	50	50	50	50	50	50	50
Female	19300	**51**	56	56	50	50	50	50	50	50	50	50
Agegroup	*p<0.001*											
15-19	3417	**9**	8	8	10	9	10	9	9	10	10	10
20-29	6017	**16**	9	8	18	17	17	17	17	19	19	20
30-39	7409	**20**	20	20	16	21	21	21	21	19	19	18
40-49	8442	**23**	21	23	23	22	22	22	22	23	22	22
50-59	7547	**20**	20	19	24	20	20	20	20	19	18	18
60-64	3933	**10**	11	10	8	11	10	10	10	11	12	12
missing	1001	**3**	11	11	0	0	0	0	0	0	0	0
Skintype	*p<0.001*											
I	4550	**12**	12	10	11	10	10	11	11	16	15	15
II	19316	**51**	51	51	52	52	53	54	51	48	50	50
III	12203	**32**	34	35	33	34	34	32	33	29	31	28
IV-IV	735	**2**	3	3	2	2	2	1	2	2	2	2
missing	962	**1**	1	1	1	1	1	1	1	1	1	1
Region	*p<0.001*											
Capital	13065	**35**	39	46	33	32	32	32	31	32	32	32
Zealand	4680	**12**	11	9	13	12	12	12	15	14	14	14
Northern Jutland	7028	**10**	10	9	10	11	10	10	10	10	10	10
Central Jutland	8086	**21**	21	18	21	22	21	22	23	23	21	23
Southern Denmark	3749	**19**	16	14	18	18	19	18	22	21	23	21
Missing	1158	**3**	3	3	5	5	6	5	0	0	0	0
Education	*p<0.001*											
< 10 years	9372	**25**	18	16	31	32	28	29	28	28	8	24
10-12 years	14881	**39**	29	28	44	45	49	49	42	40	27	42
>12 years	12909	**34**	54	55	25	22	22	21	28	31	64	32
Missing/unspecified	604	**2**	1	1	2	2	2	2	2	1	1	2
Sunbathe	*p<0.001*											
Yes	24350	**64**	72	61	65	67	65	61	60	64	66	63
No	13416	**36**	28	39	35	33	35	39	40	36	34	37
Have children	*p<0.001*											
Yes	12527	**33**	35	36	32	33	33	34	25	34	34	32
No	25239	**67**	65	64	68	67	67	66	75	66	66	68
Temperature	*p<0.001*	**15.8**	17.4	15.9	16.3	15.6	16.3	15.8	14.3	15.7	17.2	14.1
Sunhours	*p<0.001*	**241**	285	197	281	250	248	212	203	254	274	210
Days with rain /month	*p<0.001*	**14.4**	8.5	18	13.5	15.2	11.9	15.6	19.4	12.3	13.3	16.2

p-values are for χ^2-test between factor levels and year of measurement. Values are percentage except for weather variables, which are expressed in means.

Table 2 Logistic regression analysis of sunbed use (ever use) in Denmark 2007-2015 by demographic factors and annual percentage decrease in sunbed use overall and by factor levels.

Characteristic **(%)** Total (n)	Total (n)	% or mean	Crude OR (95 C.I.)	[a)]Adjusted OR (95 C.I.)	[b)]Adjusted OR (95 C.I.)	Sunbed use annual change	Sunbed use annual change (adjusted)
Total (n)	37562	18	34616	34616	34616	0.97 (0.97-0.97)	**0.97 (0.97-0.97)**
Gender			*p<0.001*	*p<0.001*	*p<0.001*		
Male	18325	13	1 (ref)	1 (ref)	1 (ref)	0.99 (0.98-1.00)	
Female	19237	22	2.78 (2.66-2.90)	3.02 (2.88-3.16)	2.66 (2.53-2.79)	0.95 (0.95-0.96)	
Agegroup			*p<0.001*	*p<0.001*	*p<0.001*		
15-19	3383	27	1.38 (1.25-1.53)	1.30 (1.17-1.44)	1.03 (0.92-1.15)	0.91 (0.90-0.92)	
20-29	5970	25	3.22 (2.95-3.51)	3.28 (2.99-3.61)	3.06 (2.78-3.37)	0.90 (0.89-0.91)	
30-39	7369	19	4.37 (4.01-4.76)	4.53 (4.11-4.98)	4.78 (4.33-5.28)	0.94 (0.93-0.96)	
40-49	8419	18	2.97 (2.74-3.23)	3.01 (2.75-3.30)	2.95 (2.69-3.24)	1.00 (0.99-1.01)	
50-59	7529	12	1.49 (1.37-1.62)	1.48 (1.36-1.62)	1.45 (1.32-1.58)	1.00 (0.99-1.00)	
60-64	3922	8	1 (ref)	1 (ref)	1 (ref)	0.99 (0.97-1.00)	
Skintype			*p<0.001*	*p<0.001*	*p<0.001*		
I	4534	13	1.08 (0.92-1.28)	0.64 (0.54-0.76)	0.80 (0.66-0.95)	0.97 (0.96-0.98)	
II	19252	18	1.19 (1.02-1.36)	0.92 (0.78-1.09)	0.99 (0.83-1.17)	0.97 (0.97-0.97)	
III	12141	19	0.96 (0.82-1.13)	0.90 (0.76-1.07)	0.93 (0.78-1.10)	0.98 (0.96-0.98)	
IV-VI	733	23	1 (ref)	1 (ref)	1 (ref)	0.98 (0.95-1.00)	
Region			*p<0.001*	*p<0.001*	*p<0.001*		
Capital	12998	15	1 (ref)	1 (ref)	1 (ref)	0.97 (0.97-0.98)	
Zealand	4652	16	0.88 (0.82-0.97)	1.15 (1.04-1.27)	0.99 (0.92-1.07)	0.98 (0.96-0.99)	
Northern Jutland	3730	21	1.17 (1.08-1.26)	0.93 (0.87-1.01)	1.30 (1.20-1.42)	0.97 (0.96-0.98)	
Central Jutland	8042	19	1.08 (1.02-1.14)	1.15 (1.08-1.22)	1.18 (1.10-1.25)	0.96 (0.95-0.97)	
Southern Denmark	6985	18	0.99 (0.94-1.06)	1.08 (1.01-1.15)	1.11 (1.04-1.19)	0.97 (0.97-0.98)	
Education			*p<0.001*	*p<0.001*	*p<0.001*		
< 10 years	9313	17	0.64 (0.61-0.68)	1.01 (0.94-1.07)	1.10 (1.03-1.17)	0.97 (0.96-0.98)	
10-12 years	7130	20	1.04 (0.99-1.09)	1.12 (1.06-1.19)	1.16 (1.10-1.22)	0.95 (0.95-0.96)	
>12 years	7682	18	1 (ref)	1 (ref)	1 (ref)	0.98 (0.98-0.99)	
Sunbathe			*p<0.001*	N.A	*p<0.001*		
Yes	24240	24	4.16 (3.85-4.49)		2.73 (2.59-2.87)	0.96 (0.96-0.97)	
No	13322	7	1 (ref)		1 (ref)	0.99 (0.99-1.00)	
Have children<18 in household			N *p<0.001*	*p=0.030*	*p=0.085*		
Yes	12461	18	1.55 (1.49-1.63)	1.06 (1.01-1.12)	1.05 (0.99-1.11)	0.96 (0.96-0.97)	
No	25101	17	1 (ref)	1 (ref)	1 (ref)	0.98 (0.97-0.98)	
Temperature (Degree celsious)			*p<0.001*	N.A	*p<0.001*		
			1.11 (1.08-1.13)		1.15 (1.11-1.19)		
Sunhours (/100/summer)			*p<0.001*	N.A	*p=0.004*		
			1.13 (1.08-1.19)		1.23 (1.07-1.42)		
Days with rain /month			*p<0.001*	N.A	*p<0.001*		
			0.99 (0.98-0.99)		1.04 (1.03-1.06)		

Odds ratios and confidence intervals (CIs). a) Model adjusted for gender, age, education, skin type, have children and region. b) Model additionally adjusted for sunbathing and weather indicators

Table 3 Projected change in number of skin cancer cases 2007-40 based on modelled scenarios of the change in sunbed use fraction 2007-15 in Denmark compared to trend.

	Projections based on campaign results 2007-15		Sensitivity variations of scenario 2			
Scenario	1 (Irreversible)	2 (Reversible)	EAPC0	EAPC30	LATLAG, Zero	LATLAG, Double
Total MM cases	111.353	111.353	63.104	154.525	111.353	111.353
Total SCC cases	136.999	136.999	83.108	184.766	136.999	136.999
Total BCC cases	414.817	414.817	254.859	547.749	414.817	414.817
ΔTotal MM	2.443 (2,2 %)	746 (0,7 %)	423 (0,7 %)	800 (0,5 %)	584 (0,5 %)	869 (0,8 %)
ΔTotal SCC	5.383 (3,9 %)	1.562 (1,1 %)	945 (1,1 %)	1.705 (0,9 %)	1.220 (0,9 %)	1.885 (1,4 %)
ΔTotal BCC	8.437 (2,0 %)	2.673 (0,6 %)	1.623 (0,6 %)	2.898 (0,5 %)	2.107 (0,5 %)	3.131 (0,8 %)

EAPC0 and EAPC30 corresponds to number of years with the estimated annual percentage change in incidence. Remaining years are constant. Main scenarios apply 15 years EAPC. LATLAG, Zero and Double, respectively is the time from an intervention is applied to the effect of the intervention on the risk factor affects the risk of cancer.

Figure legends

Figure 1

Illustration of data projections and scenarios

Figure 2A. Values are OR (95CI) sunbed use (recent use) compared with 2007 pre-campaign measurement adjusted for gender, age, education, region and skin type.

Figure 2B. Values are OR (95CI) sunbed use (ever use) compared with 2007 pre-campaign measurement adjusted for gender, age, education, region and skin type.

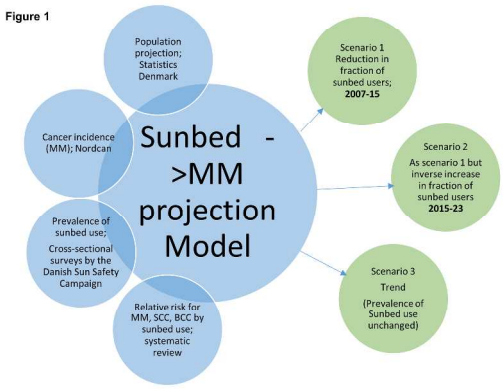
Figure 3a

The expected number of MM cases, when sunbed use is unchanged, there is a reversible or irreversible campaign effect. Assumed estimated annual percentage change 2007-2022 (4% increase) and 2022-2040 (0% constant). LAT time of 2 years and LAG time of 5 years.

Figure 3b
The expected number of SCC cases, when sunbed use is unchanged, there is a reversible or irreversible campaign effect. Assumed estimated annual percentage change 2007-2022 (4% increase) and 2022-2040 (0% constant). LAT time of 2 years and LAG time of 8 years.

Figure 3c
The expected number of BCC cases, when sunbed use is unchanged, there is a reversible or irreversible campaign effect. Assumed estimated annual percentage change 2007-2022 (4% increase) and 2022-2040 (0% constant). LAT time of 2 years and LAG time of 8 years.

Figure 1



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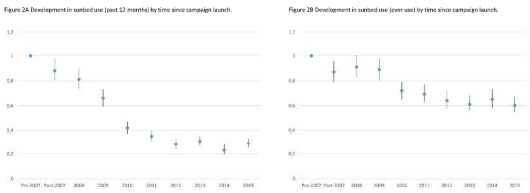

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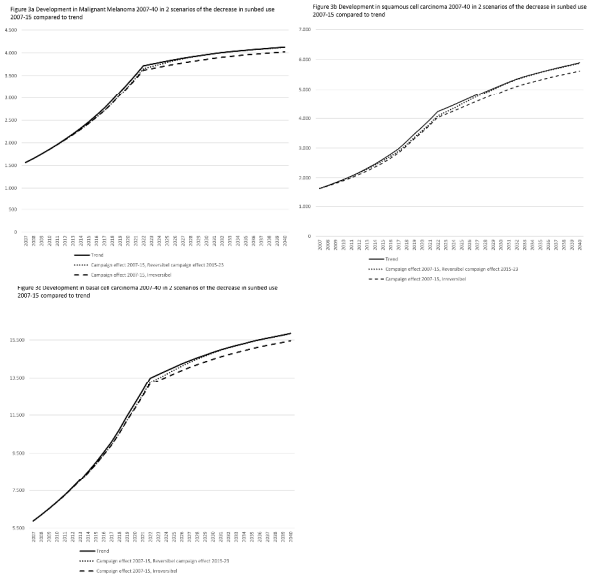

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Supplemental table S1a Percentage of sunbed use (past 12 months) by demographic characteristics and year of measurement in cross-sectional surveys in Denmark 2007-2015 of 37.766 Danes**.**

Characteristic **(%)** Total (n)	Total (n)	% or mean	March 2007 (%)	August 2007	August 2008	August 2009	August 2010	August 2011	August 2012	August 2013	August 2014	August 2015
Total (n)	37766	**18**	4303	4451	4277	4186	4156	4130	2195	4022	2047	3999
Gender	*p<0.001*		*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*
Male	18437	**13**	18	14	16	16	12	10	10	11	8	8
Female	19300	**22**	32	31	34	28	19	16	12	12	11	13
Agegroup	*p<0.001*		*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*0.008*	*p<0.001*	*p<0.001*	*p<0.001*
15-19	3417	**27**	50	48	44	33	18	12	9	13	14	15
20-29	6017	**25**	47	45	38	32	22	17	16	15	13	12
30-39	7409	**19**	31	31	28	22	14	15	11	10	8	10
40-49	8442	**18**	26	22	23	23	17	15	11	13	11	12
50-59	7547	**12**	18	16	15	14	12	10	8	9	5	7
60-64	3933	**8**	15	10	8	11	5	6	8	8	3	5
Skintype	*p<0.001*		*p<0.001*	*0.003*	*0.015*	*0.154*	*0.002*	*p<0.001*	*0.123*	*0.006*	*0.068*	*0.025*
I	4550	**13**	23	19	20	18	9	6	8	8	6	10
II	19316	**18**	24	25	26	22	16	13	12	12	9	10
III	12203	**19**	30	23	27	22	16	15	11	13	11	13
IV	735	**23**	30	33	25	27	13	21	19	17	14	16
Region	*p<0.001*		*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*0.007*	*0.008*	*p<0.001*	*p<0.001*	*0.176*	*0.487*
Capital	13065	**15**	20	21	23	18	12	10	6	8	7	10
Zealand	4680	**16**	24	26	18	21	15	13	14	12	10	10
Northern Jutland	7028	**21**	35	29	29	25	17	16	14	16	10	13
Central Jutland	8086	**19**	30	29	28	26	16	15	12	12	10	10
Southern Denmark	3749	**18**	30	20	29	22	17	13	13	13	11	12
Education	*p<0.001*		*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*0.009*	*0.024*	*0.359*	*0.067*	*0.017*
< 10 years	9372	**17**	32	29	24	20	12	12	10	11	6	9
10-12 years	14881	**20**	30	28	29	26	18	15	10	13	11	12
>12 years	12909	**15**	21	20	20	16	13	11	14	11	9	10
Sunbathe	*p<0.001*		*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*
Yes	24350	**24**	33	32	34	29	20	18	15	15	12	15
No	13416	**7**	7	11	9	8	6	5	5	6	3	3
Have children	*p<0.001*		0.198	0.028	0.233	0.596	0.240	0.087	0.414	0.320	0.771	0.155
Yes	12527	**18**	27	25	24	21	14	14	12	11	9	12
No	25239	**17**	25	23	26	22	16	12	11	12	9	10

p-values are for χ^2-test between observed and expected (average) factor levels.

Supplemental table S1b Percentage of sunbed use (ever use) by demographic characteristics and year of measurement in cross-sectional surveys in Denmark 2007-2015 of 37.766 Danes**.**

Characteristic **(%)** Total (n)	Total (n)	% or mean	March 2007 (%)	August 2007	August 2008	August 2009	August 2010	August 2011	August 2012	August 2013	August 2014	August 2015
Total (n)	37766	**52**	4303	4451	4277	4186	4156	4130	2195	4022	2047	3999
Gender	*p<0.001*		*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*
Male	18437	**39**	40	36	40	43	39	40	38	38	38	35
Female	19300	**64**	68	66	72	70	61	62	60	57	59	58
Agegroup	*p<0.001*		*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*0.008*	*p<0.001*	*p<0.001*	*p<0.001*
15-19	3417	**40**	57	57	61	51	34	28	22	23	27	22
20-29	6017	**60**	79	78	70	67	59	59	56	53	51	44
30-39	7409	**68**	77	74	71	69	66	64	65	60	62	62
40-49	8442	**59**	61	57	58	59	59	58	56	57	61	60
50-59	7547	**41**	44	40	38	45	42	44	42	40	41	40
60-64	3933	**32**	37	31	35	36	29	33	26	33	26	33
Skintype	*p<0.001*		*p<0.001*	*0.003*	*0.015*	*0.154*	*0.002*	*p<0.001*	*0.123*	*0.006*	*0.068*	*0.025*
I	4550	**52**	60	54	55	57	51	50	53	48	51	48
II	19316	**54**	56	56	58	60	55	54	50	51	52	47
III	12203	**49**	55	49	53	52	49	48	47	44	41	47
IV	735	**49**	51	53	51	53	40	47	44	46	51	46
Region	*p<0.001*		*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*0.007*	*0.008*	*p<0.001*	*p<0.001*	*0.176*	*0.487*
Capital	13065	**51**	54	52	55	55	51	51	48	47	46	47
Zealand	4680	**49**	51	54	50	54	48	48	48	46	44	43
Northern Jutland	7028	**55**	59	56	61	62	50	51	52	52	54	51
Central Jutland	8086	**53**	60	55	56	60	55	52	51	48	48	45
Southern Denmark	3749	**51**	56	50	58	51	53	50	48	48	51	47
Education	*p<0.001*		*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*0.009*	*0.024*	*0.359*	*0.067*	*0.017*
< 10 years	9372	**44**	48	44	49	49	42	41	34	40	31	41
10-12 years	14881	**56**	61	57	60	62	57	56	52	48	44	47
>12 years	12909	**54**	55	53	56	57	52	54	59	53	52	50
Sunbathe	*p<0.001*		*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*	*p<0.001*
Yes	24350	**61**	65	63	67	66	61	61	58	55	55	56
No	13416	**35**	31	36	35	37	35	36	35	34	36	31
Have children	*p<0.001*		0.198	0.028	0.233	0.596	0.240	0.087	0.414	0.320	0.771	0.155
Yes	12527	**60**	65	63	62	63	62	59	62	51	49	55
No	25239	**48**	51	47	52	53	47	47	44	46	48	43

p-values are for χ^2-test between observed and expected (average) factor levels.

Supplemental table S2 Logistic regression analysis of sunbed use (past 12 months) in Denmark 2007-2015 by demographic factors and annual percentage decrease in sunbed use overall and by factor levels.

Characteristic **(%)** Total (n)	Total (n)	% or mean	Crude OR (95 C.I.)	[a)]Adjusted OR (95 C.I.)	[b)]Adjusted OR (95 C.I.)	Sunbed use annual change	Sunbed use annual change (adjusted)
Total (n)	37562	18	34616	34616	34616	0.97 (0.97-0.97)	**0.96 (0.96-0.97)**
Gender			*p<0.001*	*p<0.001*	*p<0.001*		
Male	18325	13	1 (ref)	1 (ref)	1 (ref)	0.99 (0.98-0.99)	
Female	19237	22	1.96 (1.85-2.08)	2.12 (2.00-2.25)	1.74 (1.63-1.85)	0.96 (0.95-0.96)	
Agegroup			*p<0.001*	*p<0.001*	*p<0.001*		
15-19	3383	27	4.00 (3.48-4.60)	4.15 (3.59-4.80)	3.41 (2.94-3.96)	0.92 (0.91-0.93)	
20-29	5970	25	3.52 (3.09-4.00)	4.21 (3.67-4.83)	4.21 (3.66-4.85)	0.94 (0.93-0.95)	
30-39	7369	19	2.55 (2.24-2.90)	3.21 (2.79-3.70)	3.19 (2.77-3.69)	0.96 (0.96-0.97)	
40-49	8419	18	2.39 (2.10-2.71)	2.84 (2.47-3.25)	2.67 (2.32-3.07)	0.98 (0.98-0.98)	
50-59	7529	12	1.48 (1.30-1.70)	1.57 (1.37-1.87)	1.45 (1.26-1.66)	0.98 (0.98-0.99)	
60-64	3922	8	1 (ref)	1 (ref)	1 (ref)	0.99 (0.99-0.99)	
Skintype			*p<0.001*	*p<0.001*	*p<0.001*		
I	4534	13	0.45 (0.37-0.54)	0.32 (0.26-0.39)	0.43 (0.35-0.53)	0.98 (0.97-0.98)	
II	19252	18	0.67 (0.56-0.80)	0.59 (0.49-0.71)	0.64 (0.53-0.78)	0.97 (0.97-0.97)	
III	12141	19	0.74 (0.62-0.89)	0.74 (0.62-0.90)	0.80 (0.66-0.98)	0.97 (0.97-0.97)	
IV	733	23	1 (ref)	1 (ref)	1 (ref)	0.96 (0.95-0.98)	
Region			*p<0.001*	*p<0.001*	*p<0.001*		
Capital	12998	15	1 (ref)	1 (ref)	1 (ref)	0.97 (0.97-0.98)	
Zealand	4652	16	1.10 (1.01-1.21)	1.15 (1.04-1.27)	1.32 (1.20-1.46)	0.98 (0.97-0.98)	
Northern Jutland	3730	21	1.54 (1.40-1.69)	1.60 (1.45-1.76)	1.73 (1.57-1.91)	0.96 (0.95-0.97)	
Central Jutland	8042	19	1.36 (1.26-1.47)	1.40 (1.30-1.51)	1.51 (1.40-1.64)	0.96 (0.96-0.97)	
Southern Denmark	6985	18	1.25 (1.16-1.36)	1.30 (1.20-1.41)	1.44 (1.32-1.57)	0.97 (0.97-0.98)	
Education			*p<0.001*	*p<0.001*	*p<0.001*		
< 10 years	9313	17	1.13 (1.05-1.22)	1.25 (1.15-1.36)	1.37 (1.26-1.49)	0.96 (0.95-0.96)	
10-12 years	7130	20	1.40 (1.23-1.40)	1.25 (1.17-1.34)	1.37 (1.28-1.47)	0.96 (0.96-0.97)	
>12 years	7682	18	1 (ref)	1 (ref)	1 (ref)	0.98 (0.97-0.98)	
Sunbathe			*p<0.001*	N.A	*p<0.001*		
Yes	24240	24	4.16 (3.85-4.49)		3.47 (3.20-3.77)	0.96 (0.96-0.96)	
No	13322	7	1 (ref)		1 (ref)	0.99 (0.99-0.99)	
Have children<18 in household			N.S.	*p<0.001*	*p<0.001*		
Yes	12461	18	1.01 (0.96-1.07)	0.87 (0.81-0.93)	0.94 (0.89-0.99)	0.97 (0.97-0.98)	
No	25101	17	1 (ref)	1 (ref)	1 (ref)	0.97 (0.97-0.97)	
Temperature (Degree celsious)			*p<0.001*	N.A	*p<0.001*		
			1.29 (1.26-1.33)		1.51 (1.44-1.59)		
Sunhours (/100/summer)			*p<0.001*	N.A	*p=0.023*		
			1.14 (1.09-1.19)		1.25 (1.05-1.49)		
Days with rain /month			*p<0.001*	N.A	*p<0.001*		
			0.96 (0.95-0.97)		1.07 (1.05-1.09)		

Odds ratios and confidence intervals (CIs). a) Model adjusted for gender, age, education, skin type, have children and region. b) Model additionally adjusted for sunbathing and weather indicators

STROBE Statement—checklist of items that should be included in reports of observational studies
Items are present at PageX and LineY: PXLY

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract: P3L4
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found P3
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported P4L3-P4L25
Objectives	3	State specific objectives, including any prespecified hypotheses P4L47-P5L2
Methods		
Study design	4	Present key elements of study design early in the paper P5L6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection P5L12-23
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants P5L12-23
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable P5L12-P5L36
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group P5L38-P6L8
Bias	9	Describe any efforts to address potential sources of bias P5L12-36
Study size	10	Explain how the study size was arrived at P5L12-23 and table1
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why P5L38-P6L8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding P5L38-P6L8
		(*b*) Describe any methods used to examine subgroups and interactions P5L12-P6L8
		(*c*) Explain how missing data were addressed Not relevant due to sampling methodology
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy P5L7-P6L8
		(*e*) Describe any sensitivity analyses P7L25-27

Continued on next page

Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed P7L31-43, Table 1
		(b) Give reasons for non-participation at each stage P7L31-43, Table 1
		(c) Consider use of a flow diagram Not relevant
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders P7L31-43, Table 1-2
		(b) Indicate number of participants with missing data for each variable of interest Table 1
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures Table 2
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included P8L12-39, Table 3, Figure 3
		(*b*) Report category boundaries when continuous variables were categorized Table 3
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period P8L12-39, Table 2-3, Figure 3
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses P8L34-39, Tabel 3
Discussion		
Key results	18	Summarise key results with reference to study objectives P9L1-6
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias P9L8-28
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence P9L30-37
Generalisability	21	Discuss the generalisability (external validity) of the study results P9L39-P10L12
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based P10L27

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.